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THE PEKILO SYMPOSIUM 12. - 15. September 1978

INTRODUCTION

The Pekilo process is a manufacturing process of a single cell protein (SCP), where cell mass with high crude protein percentage is produced by means of cultivating mycelia-forming fungi (Paecilomyces) in a suitable solution containing carbohydrates.

The process has originally been developed by the Finnish Pulp and Paper Research Institute, and the process techniques have been developed by Oy Tampella Ab and United Paper Mills Ltd in cooperation.

The first industrial application, the Pekilo Mill, has operated since 1975 at the Jämsänkoski Mills of United Paper Mills Ltd. The production of sulfite pulp leaves waste liquor containing sugars and organic acids. This spent sulfite liquor is used as raw material for the Pekilo process.

The significance of the Pekilo process in view of the protection of the environment is quite important since in the course of the process an ample amount of particles that cause biological oxygen consumption, i.e. water pollution, is removed from the waste liquor.

The production capacity of the Jämsänkoski mill is 10 000 tons of Pekilo product per year, i.e. 10 - 15 % of the cellulose production. By its consistency the Pekilo product corresponds feed yeast and is used as substitute for soya- and fish meals in feed mixtures for swine and poultry.

In Finland Pekilo was accepted for animal feed purposes in 1971, but its suitability for different feed mixtures is further studied at the Agricultural Research Center.

Since 1973 tests aiming at the qualification of this product as animal feed have been performed also in Norway, England, Czechoslovakia, Soviet Union, Poland, Bulgaria, Yugoslavia and Portugal.

Tampella has organized an International Symposium on September 12 - 15, 1978, in which representatives from different countries described their respective experiences of the use of Pekilo. The Symposium is part of this year's programme of Soviet-Finnish scientific-technical co-operation in the field of agriculture. In addition to the Soviet delegation representatives from Bulgaria, Norway, Poland, Czechoslovakia and Finland participated in the Symposium.

The purpose of this four-day specialist meeting was to familiarize the participants with all research work done in respect of the uses of Pekilo.

The Symposium bears significance mainly to present and future users of the Pekilo product, as well as to the organizer of the Symposium, Oy Tampella Ab, in view of marketing.

PEKILOSYMPOSIUM HELD IN TAMPELLA TAMPERE

12. - 15. SEPTEMBER 1978

SEPTEMBER 12, 1978

Chairman	L Syrjälä, acting prof
Secretary	T Alaviuhkola, M.A.

1 At 9.15 opening of the meeting by prof Syrjälä.

2 Tampella's introduction by director A Karhola.

3 Composition of Pekilo and feed value by Dr Salo.

During the general discussion, a question (Alaviuhkola) concerning variation between different lots of Pekilo was brought forward. According to Tampella's representative (Lehtomäki) the industrial process is continuously developed and protein content of the product can be standardized close to what was present in that pilot plant product, with which the first experiments were performed upon.

Dr Plonka (Poland) asked, whether any residues of heavy metals have ever been found in Pekilo? Dr Salo's reply indicated, that the levels have been very low. Salo also mentioned that difference between crude fibre content in Pekilo and Torula-yeast is partly due to analysis technic.

4 Agr. Ojala informed that in 1977, quantity of Pekilo used by Finland's feed industry was 2100 tons. In the feed mixtures of pigs and chickens Pekilo's percentage is about 3 %. Pekilo has not been used in the milk replacers. Handling of Pekilo in the industry is easy and without problems.

During the general discussions it was clarified that finnish feed industry imports feed yeasts quite a lot, so that half of the SCP-products are from abroad.

5 Dr Koivurinta presented Pekilo in view of the human consumption and verified it as being technically quite easy to apply to such purpose. However, the taste is still a problem in many products.

6 Alaviuhkola presented experiments performed in Finland with the pigs. According to these experiments, up to 2/3 of the protein in the diet of growing finishing pigs can be replaced with Pekilo without any side effects. Experiments with sows and piglets have been started at the Swine Research Station, Hyvinkää (Finland).

7 Chairman read an abstract concerning very favourable results on Pekilo experiments performed in England.

8 Hanssen presented Norwegian experimental results. He confirmed that Pekilo can replace soya meal in feeding the growing finishing pigs on the basis of crude protein.

Dr Bobrov presented results of the experiments performed in the Soviet Union. According to them Pekilo has the same value as the yeast protein.

9 According to Dr Plonka, Polish Pekilo-experiments prove that Pekilo can without any difficulties relace both fishmeal and oilextractives in the mixtures of the pigs. Pekilo had a slight positive effect on the quality of the carcass. Quality of the meat was judged by measuring the chemical composition, pH and water binding capacity on the samples taken from the musculus longissimus dorsi. Effect of Pekilo did not differ from other protein feeds.

10 In the absence of Yugoslavian representatives Mr Lehtomäki from Tampella presented the results of Pekilo experiments performed in Yugoslavia. According to them the Pekilo produced about 9 % lower growth and 5.8 % poorer feed utilization than the fishmeal. Lysine- and methionine additions will bring Pekilo into the comparable level with the fishmeal. Yeast and Pekilo are quite compensable with each other.

11 During the general discussion Mr Ingman from Tampella verified that Pekilo-method can be well adapted beside the sulphite waste liquors also for utilization of other carbohydrate wastes, e.g. molasses and hydrolyzed wood.

SEPTEMBER 13, 1978

Chairman	V Kossila	Dr
Secretaries/AM	T Alaviuhkola	M.A.
PM	T Kiiskinen	MMK

12 Kiiskinen presented the Pekilo-experiments performed in Finland with the poultry. Preliminary experiments at the beginning of nineteenseventies did not give the actual picture of possibilities to use Pekilo, because methionine addition was not used. According to Kiiskinen, Pekilo can be used as a sole protein feed of the laying hens. Also in the feed of chickens and broilers main part of additional protein (fishmeal, soya meal) can be compensated with the Pekilo.

13 Hanssen (Norway) informed about experiments concerning nutritional value of Pekilo and also of feeding experiments with chickens. Digestibility of protein varied in different Pekilo-samples. Digestibility of amino acids was in average same class as in soya meal. Availability of lysine was in average somewhat lower than in soya meal, as well as PER-value determined with chicks. According to Hanssen, Pekilo might compensate the soya meal as the protein source, presuming that methionine is added into the feed.

14 During the general discussion Romantschuk from Tampella presumed that different heating methods of Pekilo lots, which were tested at that time might have had reflect upon the results of Norwegian experiments.

Alaviuhkola wished to get information on available lysine of the Pekilo.

15 Tshikov from the Soviet Union presented Pekilo-experiments performed on ducks and broilers. There was 8 % of fishmeal present in the control feeds, which was stage by stage compensated with the Pekilo and in the duck experiment also with yeast (2,4,6 %). On the ducks, yeast and Pekilo proved to be equal. No side effects were noticed.

On the broilers, 75 % of the fishmeal could be replaced by Pekilo (6 % in feed) without reduction in growth rate or feed conversion. When quality of the carcass was taken into consideration, 50 % (4 % in feed) proved to be optimal.

16 Lehtomäki (Tampella) inquired about the upcoming Pekilo experiment program in the Soviet Union. According to the given reply Ministry will decide upon the actual program. Pekilo and hydrocarbon yeast experiments will be started with the early weaned lambs.

17 Lehtomäki presented Pekilo-experiments performed with the poultry in Yugoslavia (Delič and Lazor). When fishmeal was completely replaced with Pekilo in the broiler feed, it resulted poorer growth and feed utilizing ratio ($P < 0,01$). Methionine addition (0,1 %) improved results up to the level of control group. Feed yeast and Pekilo were equal.

18 Granulation of Pekilo and its necessity and its possible effect upon quality of protein was under discussion (Plonka). From point of view of the industry, granulated product is easier to handle and temperature of 60-70°C does not decrease quality of the product (Korhonen).

Plonka suggested that palatability of granulated and ungranulated Pekilo should be estimated in a future experiment.

19 In the experiments performed in Bulgaria (Surdgiiska) with broilers, compensation of yeast (5 %) and soya meal with 5-10 % of Pekilo did not have effect upon growth or feed efficiency. 3.4-bentsbyrene was not found in the Pekilo or in meat of broilers fed with Pekilo-containing feed.

20 According to Polish experiments, (Korniewicz and Plonka), Pekilo can compensate at least 2/3 of the soya meal in feed of the broilers. Pekilo had a very positive effect upon feed conversion. Pekilo did not have any harmful effect upon health of the animals, carcass quality and chemical composition of the carcass. Protein level and Asp AT-activity (aspartate aminotransferase) of the blood serum showed that biosynthesis of the amino acid was unbalanced when the soya meal was compensated with Pekilo.

21 During following discussion, Dr Kossila inquired about soluble proteins in the breast muscles. Reply: Primarily gammaglobulines. To Kossila's inquiry Polish replied that Asp AT-activity shows speed of the protein synthesis and that its drop in this case showed that quality of soya meal protein was better than Pekilo's.

22 Kossila and Plonka presented experiences on using Pekilo in feeding of the calves. According to the experiments performed in Finland, Pekilo is not well suited for milkreplacers of very young calves. From about age of one month on, it can be used together with dried whey to compensate skim milk powder, either in the milkreplacers or in the starters. In Poland the test results indicated that Pekilo was even better than dried skim milk, but the calves were already about 7 weeks old, when the experiment was started.

23 Romantschuk asked whether the results of Polish and Finnish calf experiments were contradictory. According to Kossila starting age is decisive factor. According to Plonka quality (heating) of milk powder protein and mineral contents can have an effect upon test results.

24 Chairman read German abstract on the research performed in Czechoslovakia, which consisted the feed value of Pekilo in the feeding of broilers. Feed yeast was used as a control and quantity used in feed was 6 % for both. Pekilo gave significantly ($P < 0,05$) better growth (index 104,3/100). Either toxic symptones or deleterious effects upon quality of the meat were not found.

25 Lehtomäki presented the variations in the composition of Pekilo from year 1963 on. Protein content has varied from 40 to 60 %. Growth speed of microbe have an effect upon the protein content of Pekilo. RNA increases according to rate of protein synthesis. When growth is very active, certain amount of carbohydrates of the cell walls is compensated with protein. Following variations in the composition of Pekilo has been found:

- protein	51 - 63 %
- total-N	8,2 - 10,1 %
- nucleic acid	9,6 - 10,8 %
- Na-N	1,9 - 2,2 %

According to Mr. Marila (United Paper Mills), the protein content of the Pekilo at the Jämsänkoski mill is at present 53 - 55 %.

26 Chairman summarized the facts brought forward in the symposium:

- During this symposium, which was organized by Tampella and who acted as the host, we have acquired a great deal of knowledge on the production, chemical composition and quality of the Pekilo. Feed industry's ideas and opinions were heard. Also information on characteristics of the Pekilo as a possible raw material in the food industry was obtained.

  Pekilo-experiments with the domestic animals (pigs, poultry, calves) have been performed in several different countires: Bulgaria, Great-Britain, Yugoslavia, Soviet Union, Norway, Poland, Czechoslovakia and Finland. According to performed experiments skim milk powder, fishmeal, oilextractives and yeast can be partly or totally replaced by Pekilo in the feed of the growing finishing pigs. It was found out during these experiments that Pekilo had neither harmful effect on the carcass or quality of lean meat nor any pathological effects. When the growth results have been poorer with the Pekilo than for example with the fishmeal, it has most likely been due to lack of methionine.

  In the diet of the laying hens, Pekilo can completely compensate soya meal and fishmeal. Sufficient amount of methionine must be added, because it is the first limiting amino acid in the single cell protein (SCP). Also in feeding of chickens and broilers considerable amount of the protein feeds can be replaced by Pekilo. Use of the fishmeal especially in the broiler feeds, is however, recommended. According to the experiments, Pekilo did not cause any harm to health of the poultry or quality of the meat.

  According to the experiments performed in Finland and Poland, Pekilo can replace dried skim milk in dry starter-feed of young calves. Pekilo can be used together with dried whey in milkreplacers for older calves. Pekilo cannot be recommended for the milkreplacers of calves between one week and one month; neither are other SCP-products recommended. Young calves digest other proteins than milk protein quite incompletely.

27 Chairman closed the meeting at 4.30 pm. She expressed thank to the participants, to lecturers and to Tampella who had organized this symposium.

LIISA SYRJÄLÄ VAPPU KOSSILA

Chairmen

TIMO ALAVIUHKOLA TUOMO KIISKINEN

Secretaries

CHEMICAL COMPOSITION AND FEED VALUE OF THE PEKILO

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Pekilo is the trade name for the mycelium forming microfungi Paecilomyces varioti, which is cultivated in the sulphite spent liquor. The Pekilo process has been developed in Finland(FORSS 1973) and the product is manufactured by United Paper Mills Ltd, Jämsänkoski.

Granulated Pekilo is light yellow, almost odourless and mild tasting feed. Due to the mycelium like structure of microbe, the product is not as dusty and finely divided as the feed yeast. Its taste is appealing to the animals.

Chemical composition

The composition of Pekilo is close to the yeasts. This can be noted also from Table 2, where average results of the standard feed analysis of Pekilo and Torula-yeast (Candida utilis) are presented. The values come from the products cultivated in the sulphite spent liquor under industrial scale. Fairly large differences in the composition can be found in the literatures, because it is characteristic of the single cell protein (SCP) that the composition varies, if changes occur in the cultivation conditions. The fact that the methods of the standard feed analysis are composed on the common plant material, has also effect upon the results. All of them are not suitable for analysing of microbe mass.

The standard feed analysis gives only a rough picture on the composition of Pekilo. In the following more specific methods have been used to clarify this picture.

Crude protein

Protein is the most important component of Pekilo. The crude protein level might change within 40 to 60 percent of dry matter, but in the industrial production the content seems to stay near to 50 percent. The amounts which were cultivated in the small fermenter contained crude protein often five

or even fifteen percentage units more (HEIKKILÄ 1973, VÄLIMÄKI 1973).

Because SCP is produced for feeding of non-ruminant animals, the amino acid composition of protein is a very important factor. In this respect Pekilo is an excellent feed and similar to the feed yeasts. The amino acid composition is shown in Table 2, the figures being averages of many researches. Characteristic of Pekilo - as of SCP generally - is the good lysine value. It is better than in soya meal, being however, poorer than in fish meal. Contents of most other essential amino acids are also high. The only defect is the low level of sulphur amino acids. This is, however, the deficiency which is more easily corrected than the poor lysine content, because most basic feeds contain quite plenty of the sulphur amino acids, and in addition, the synthetic DL-methionine is inexpensive when comparing to the synthetic L-lysine.

Table 3 has been taken as an indication of the fact that the feed combination improves the biological value (BV) and the net protein utilization (NPU) of SCP. In addition to the values for BV and NPU of the separate yeasts and of barley, Table 3 gives the results for the combinations of barley and yeasts, and of barley and fish meal. For both protein criteria, the combination of yeast and barley gives good values, similar to those from combining good fish meal with barley (SCHULZ and OSLAGE 1976).

The low content of the sulphur amino acids is typical also to the legume seeds, e.g. soya meal, and therefore Pekilo is suitable for compensating soya meal in the feed mixtures, but not for supplementing it. The fish meal or some other animal feeds are suitable supplementary feeds.

A part of the SCP nitrogen is included in the nucleic acids. In general, their content is proportional to the grow rate of the cell mass. Values of 5 to 12 % nucleic acid for yeasts and 8 to 16 % for bacteria in the dry matter are given, corresponding 10 to 20 % of total nitrogen (KIHLBERG 1972). The nucleic acid content of Pekilo is, according to the producer, 10 to 11 % of dry matter, corresponding about 22 % of total nitrogen. (The ribose content of the hydrolysates (Table 5) is an indication of the existence of nucleic acids). In the field of human nutrition the extension of nucleic acid intake above the tolerated amount of 1 to 2 g per day, should be avoided. In the case of agricultural animals, however, the order of magnitude of nucleic acid intake which may lead to a negative effect on performance is at present not clear (SCHULZ and OSLAGE 1975).

It is known, however, that nucleic acids decrease the utilization of the crude protein. For example, growing pigs utilize 1/3 to 1/4 of purine and pyrimidine nitrogen, and excrete the rest within the urine in the form of allantoin (ROTH and KIRCHGESSNER 1977).

Carbohydrates

Carbohydrate composition of SCP differs greatly from higher plants. The chief constituents are glucan and mannan, followed by galactan and chitin. Xylan and araban, which are characteristic of higher plants occur only in traces and possibly are residues from the sulphite spent liquor (SCHULZ and OSLAGE 1976, SALO 1977).

In the standard feed analysis carbohydrates are included in the groups of crude fibre and N-free extract, the value of crude fibre describing the bulkiness of the feed. For analysing of SCP the crude fibre technique suits poorly, because SCP does not contain crude fibre in the same meaning than the common feeds. The crude fibre value is also depending on the tightness of the filter used in the determination. As an example of it are the following figures: when a glass wool filter is used, the crude fibre value for Pekilo is about 7 %, but when the filtering takes place through an asbestos filter the value will rise to 10 %. The difference with yeasts is even larger (0 - 2 % contra 7 %), because yeasts are not filamentous like Pekilo. This technical point is the main reason for the large variation in the crude fibre content of SCP presented in the literature (SALO 1977).

Table 4 shows the carbohydrates devided into fractions according to their solubility. Determination was performed with an extraction and hydrolysis system developed for the plant materials. The final determination of each fraction was made as reducing sugars (SALO 1965). It can be seen that the sugar contents of Pekilo and yeasts are low and no starch is present. The largest fraction is the hemicellulose. However, about 8 % of Pekilo and somewhat less of yeasts are such polysaccharides which require as strong hydrolysis as cellulose. This poorly soluble carbohydrate fraction agrees fairly well with the crude fibre percentage.

The solubility of carbohydrates in pepsin-HCl and amyloglycosidase incubations was found to be low (SALO 1977). Consequently, the SCP contains only small amounts of carbohydrate material that animals are able to utilaze without the aid of alimentary microbes. This result agrees with the findings of GAILLARD

and WEERDEN (1976) that the cell wall polysaccharides of yeast are digested very little by the normal digestive enzymes of the calf's small intestine, but are used as a substrate by the bacterial flora of the large intestine. The low solubility of carbohydrates might give the explanation also to the finding that Pekilo is a rather problematic feedstuff in the feeding of pre-ruminant calves. That the same is not true with the pigs, is depending on the fact that the digestion system of pigs is greatly based on the microbial function in the alimentary tract.

The crude lignin percentages shown in the Table 4 describe the residues after acid hydrolysis. The term is inside the quotation marks, because microbe cells hardly contain any lignin. The nitrogen content of this crude lignin was similar to that of plant materials rich in protein.

Table 5 shows the rough percentage distribution of different sugar units respect to the total carbohydrates. The main component is glucose, which is present in all three fractions, but especially in the hemicellulose. Glucosan similar to starch does not occur.

Crude fat

According to the most researches the ether extract value of Pekilo is only 1 to 2 % of dry matter, in a few samples however, up to 5-6 % (HEIKKILÄ 1973, SALO 1977). Because the ether dissolves only a part of the total fat, the determination is often completed with prehydrolysis with hydrochloric acid. This method gives values for Pekilo and yeasts which are about three times as high as the simple ether extracts, as is shown in the following combination (SALO 1977):

	Ether extract	HCl-ether extract
Pekilo No. 1	4,6	6,8
Pekilo No. 2	1,4	5,0
Torula	1,9	6,2
Saccharomyces cerevisiae	1,8	7,9

Fairly large variation have been stated both in the magnitude and the composition of the total fat fractions of the yeasts and the bacteria. Besides triglycerides and fatty acids a high unsaponifiable portion may be present. Fatty acids are mainly of type C_{14} - C_{18} and unsaturated fatty acids predominate (SCHULZ and OSLAGE 1976). The proportions of linoleic and arachidonic acids are, however, very low (BECK and GROPP 1974).

Minerals

Many researchers have determined the mineral contents of Pekilo and yeasts. Differences are observed also in this area. General feature is that SCP contain plenty of phosphorus (about 1,5 %) and very little of calcium. From the trace minerals especially zinc is plentiful (about 140 ppm.) and according to some researchers also manganese. Contents of heavy metals have been found safely low.

Vitamins

The well known fact is that single cell products are rich sources of the vitamin B group and they form thus an excellent vitamin B supplement for the feed industry. The vitamin composition of SCP is, however, deficient because the fat soluble vitamins, vitamin C and also B_{12} are missing. Table 6 shows the order of magnitude of vitamins. In order to show the difference between vitamin B contents of SCP and cereals, also barley is presented in the same Table.

Toxic substances

No poisonous substances have been found in the Pekilo. Neither there is any risk of the carcinogenous polycyclic hydrocarbons as it is the case with the petroproteins. Contents of heavy metals have been stated low.

Digestibility and feed value

Many feeding trial have been performed with Pekilo, but the digestibility experiments are limited to one trial with fattening pigs, weight 23 to 68 kg (VÄLIMÄKI 1973), and two trials with calves (HEIKKILÄ 1973). Not even those experiments have been published in the official sources of information. Digestibility coefficients are shown in Table 7, and feed units (F.u.), metabolizable energy (ME) and digestible crude protein (DCP) values in Table 8.

In the same Tables corresponding values for yeasts, found in the literature, are presented.

The test with pigs showed that pigs digest Pekilo very well. Also the nitrogen balance was found equal with other protein feeds. The digestibility experiment thus confirmed the results of feeding trials, where Pekilo had proved to be very good pig feed,almost equal to the fish meal. However, the

digestibility results are not reliable enough, because the proportion of Pekilo was only 11 % of the diet, and the digestibility coefficients of the basic feed, barley, were taken from the Feed Table. Apparently this is the reason that the figures of the trial are not published.

In the trial with calves (age about 2 months) the Pekilo was the only feed, instead. The quantity was small, only 380 g/d, because the calves did not eat more, and due to that the nitrogen balance formed quite negative. Digestibility coefficients were lower than with pigs, especially those of the non-protein substances.

In the other trial Pekilo was as an ingredient in the diet of 3 to 7 week old calves. The two trials showed that the ability of pre-ruminant calf to digest Pekilo increases within the age. Pekilo is not, however, as good feed for calves as for pigs.

Digestibility results for poultry are not available, but according to feeding trials Pekilo is suitable for poultry as long as its quantity is limited to about half of the required protein supplement.

No tests have been performed with adult cattle, because Pekilo is considered to too expensive feed for ruminants.

All in all it can be verified that the digestibility of the most important component of Pekilo, the crude protein, has proved to be good, and at least with pigs also the utilization of protein has been good. Digestibilities of other organic substances have been poorer and differences greater between animal species.

Table 1. Average values of standard feed analysis, percentages of dry matter.

	Ash	Crude protein	Ether extract	Crude fibre	N-free extract
Pekilo	6	50	2	7	35
Torula	7	50	2	2	39

Table 2. Average values of the main essential amino acids, g/16 g N

	Pekilo	Torula
Lysine	6,1	7,7
Methionine	1,5	1,3
Cystine	0,8	0,8
Threonine	4,5	5,2
Tryptophan	1,4	1,4
Valine	4,9	5,6
Isoleucine	4,2	5,1
Leucine	6,7	7,6
Phenylalanine	3,8	4,5
Arginine	6,1	5,1
Histidine	2,0	2,1

Table 3. The effect of combining barley with yeast on biological value and net protein utilization for pigs (60 % protein of barley + 40 % of yeast) SCHULZ & OSLAGE 1976).

	BV		NPU	
	%		%	
Barley	61,2		53,8	
Yeast (methanol)	74,6		65,9	
" + barley		82,6		73,1
Yeast (T) (n-paraffin)	80,1		75,3	
" " + barley		77,9		69,0
Yeast (n-alkanes)	68,2		61,7	
" + barley		78,9		68,9
Yeast (whey)	79,3		70,3	
" + barley		77,8		70,4
Fish meal	85,4		83,4	
" + barley		77,9		71,4

Table 4. Carbohydrate composition of SCP, percentages in dry matter (SALO 1977)

	Pekilo 1		Pekilo 2		Torula		Bakers' yeast	
Sugars	1,1		0,5		3,7		0,8	
Hemicellulose	24,5		27,2		23,1		26,2	
sugar anhydrides		22,2		24,8		19,4		23,8
uronic anhydrides		1,2		1,0		3,0		1,0
hexosamine anhydrides		1,1		1,4		0,7		1,4
Cellulose	7,6		8,4		4,9		6,2	
sugar anhydrides		4,0		4,9		3,7		5,5
hexosamine anhydrides		3,6		3,5		1,2		0,7
Total carbohydrates	33,2		36,1		31,7		33,2	
"Crude lignin"	4,5		4,8		5,0		5,3	
6,25 x N		1,1		1,2		1,3		0,8
residue		3,4		3,6		3,7		4,5

Table 5. Percentage distribution of carbohydrate constituents (SALO 1977).

	Pekilo	Torula	Bakers' yeast
Glucose	66	55	48
Mannose	6	18	42
Galactose	10	6	-
Xylose	+	2	-
Arabinose	-	2	-
Ribose	1	1	1
Uronic acids	3	10	3
Hexosamines	14	6	6
	100	100	100

Table 6. Vitamin contents, mg per kg.

	Pekilo	Yeasts	Barley
Thiamine	6-8	3-90	4
Riboflavin	36-66	44-183	2
Pyridoxin	10-16	25-57	5
Niacin	272-488	125-523	80
Panthotenic acid	26-35	10-125	7
Biotin	2	1	0,1

Table 7. Digestibility coefficients of SCP for pigs, calves and poultry.

	Organic matter	Crude protein	Crude fat	N-free extract	Crude carbohydrates	Reference
Pigs						
Pekilo	81	87	76	84	-	VÄLIMÄKI, 1973
Yeast	77-89	93-93	71-77	-	23-83	SCHULZ & OSLAGE, 1976
Calves						
Pekilo	71	75	39		69	HEIKKILÄ, 1973
Yeast						
Poultry						
Yeast	78	85	78	61	-	BECK & GROPP, 1974
		84				KOSAKA et al. 1972

Table 8. Energy and DCP values of SCP per kg dry matter.

	Feed units x)	Metabolizable energy, Mcal	DCP g	References
Pigs				
Pekilo	1,12	3,52	502	VÄLIMÄKI 1973
Yeast	-	3,51	595	SCHULZ & OSLAGE 1976
Calves				
Pekilo	0,96	-	476	HEIKKILÄ 1973
Yeast				
Poultry				
Yeast	-	2,66		WALDROUP 1971
		2,60-3,48	403-538	KOSAKA et al. 1972

x) Fu = 0,7 x starch units

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Matti Lehtomäki
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THE VARIATION OF THE CHEMICAL COMPOSITION OF PEKILO-PRODUCT

Pekilo-product has been investigated since 1963 when the first portion of this fungal biomass was harvested from the shake flask culture.
Over a period of ten years also animal feeding tests have been done in different countries. The chemical composition, mainly crude protein content of the samples used in these tests, has varied in wide ranges. Crude protein content (N x 6.25) was referred as being from 40 to 60 %.

The process has been studied systematically during the three years industrial operation in order to improve design further and to develope process control.
The following figure shows how the protein content of Pekilo increases by increasing growth rate during fermentation. Growth rate is the same as dilution rate in steady state of the continuous cultivation.

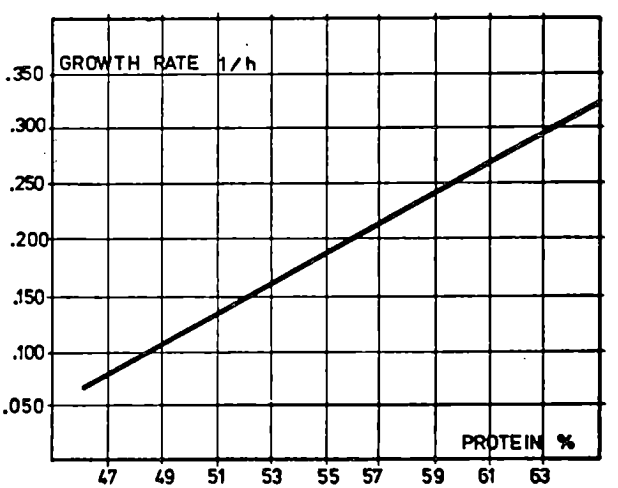

Fig.1 CORRELATION BETWEEN PROTEIN CONTENT AND SPECIFIC GROWTH RATE

The main reason to this variation is behaviour of the organism itself. All micro-organisms have a clear correlation between growth rate and total N-content of the cell. This correlation in bacteria and yeasts depends mainly on the RNA-content dealing with protein synthesis in cells. The variation is however more distinct with filamentous fungi because the share of thinwalled hyphal tips increases effectively with faster growth rate. Accordingly certain amount of carbohydrates included in the cell wall is compensated by protein in higher growth rates.

About 16 % of the increase in Pekilo-protein is derived from the RNA as shown in the following calculation:

- Crude protein %	51	63
- Total N	8.2	10.1
- Nucleic acids (NA) %	9.6	10.8
- NA-N	1.9	2.2

increase of NA-N/increase of total N

= 2.2-1.9/10.1-8.2 = 0.3/1.9 (15.8 %)

On the base of this theoretical view the reasons of variation can be realized in different samples studied during the development of Pekilo process.

The high growth rate can be obtained only by opti mization of all factors affecting to cultivation conditions. This includes both mechanical and biochemical operation of the fermentation. For example breaks in energy and raw material supply as well as disturbancies in process equipment have fast influence also to the end product.

The operation of the whole production line without disturbances is needed to get the product of good and even quality

During the development of industrial process in Jämsänkoski Pekilo mill since 1975 significant improvement has been obtained in the optimization of the process. Good indication of this proceeding might be the recent highly increased production and improved quality of the product.

Typical chemical composition of Pekilo is shown in table 1.

TABLE 1

TYPICAL COMPOSITION OF PEKILO-PROTEIN OBTAINED FROM Ca-SPENT SULPHITE LIQUOR

ELEMENTS (PPM)			AMINO ACIDS %		VITAMINS (PPM)	
Fluoride	R	4	Aspartic acid	8.5	THIAMINE	7
Arsenic	As	0.1	Threonine	4.8	RIBOFLAVIN	70
Copper	Cu	12	Serine	4.2	PYRIDOXIN	25
Manganese	Mn	115	Glutamic acid	10.7	NIACIN	450
Cobalt	Co	1	Proline	3.6	PANTHOTHENIC ACID	60
Zinc	Zn	140	Glycine	4.6	BIOTIN	2
Lead	Pb	< 1	Alanine	6.0	FOLIC ACID	20
Cadmium	Cd	0.1	Valine	5.0		
Phosphorus	P	1500	Methionine	1.6		
Sodium	Na	1000	Isoleucine	4.6	FEED ANALYSIS	%
Potassium	K	10000	Leucine	7.1	Moisture, max.	6
Calcium	Ca	3000	Tyrosine	4.0	Crude fat	1.3
Magnesium	Mg	1000	Phenylalanine	4.2	Crude protein	55
Iron	Fe	200	Ornitine	0.5	Crude fiber	7
Chromium	Cr	0.4	Lysine	6.5	N-free extracts	25
Sulphur	S	5000	Histidine	2.0	Ash	6
Selenium	Se	0.1	Arginine	6.5	Digestible crude protein (pepsin-HCL-meth)	46
Molybdenum	Mo	0.1	Cystine (+ Cysteine)	1.0		
Iodine	J	0.5	Tryptophan	1.5	1/feed units	0.95
Mercury	Hg	< 0.05				

FUNCTIONAL PROPERTIES OF PEKILO^{R}, A MICROFUNGUS BIOMASS FROM PAECILOMYCES VARIOTI, AS COMPARED TO SOYA, TORULA AND CASEIN PRODUCTS IN FOOD SYSTEMS

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SUMMARY

The functional properties (protein solubility, water and fat binding, gelling, emulsifying and foaming ability of Pekilo, a microfungus biomass from Paecilomyces varioti produced by the so called Pekilo process developed in Finland, were studied and the applicability of Pekilo biomass in some test food products (cakes, breads, sausages, meat balls) was investigated. Mavar, Soyafluff 200 T, Torula and Torutein were used as reference materials.

The protein solubility of conveyor dried Pekilo was superior to the drum dried Pekilo. The isoelectric point of the former was about pH 4.2. The protein solubility of Pekilo biomass was not affected by the NaCl concentration but the solubility decreased when the suspension was heated to 90 °C. The water binding of Pekilo biomass varied greatly according to the analytical method used, ranging from 1.9 to nearly 6.0 ml/g. Fat binding was dependent on the bulk density of the material. Conveyor dried Pekilo emulsified 35 ml of oil/g of sample. The emulsions were not affected by NaCl (2 %) and the stability of the emulsions was improved by heating and slightly impaired by freezing.

Conveyor dried Pekilo was able to form gels at concentrations of 8 % and above. Ionic strength ($NaCl$, $CaCl_2$) did not affect the gelling ability. This property was the better the higher the protein solubility was. Conveyor dried Pekilo biomass could be whipped at 5 % suspension into foams comparable to that of egg white. Egg white and whole egg can be partially substituted with Pekilo biomass but the concentration of the Pekilo suspension used for this purpose has a profound effect on the results. Meringues baked using Pekilo suspension to partly substitute egg white were inferior to the control.

The volumes of cakes (fat free cake A, and fat containing cake B) were decreased with increasing substitution of egg by conveyor dried Pekilo biomass. The mild flavor of Pekilo powder was distinctly observable in the organoleptic evaluation, being stronger in cake A than in cake B. Conveyor dried Pekilo biomass increased the water binding of the doughs. The stability and extensographic properties of doughs containing Pekilo were inferior to the control, resulting in wheat breads with a specific weight higher than that of control bread. Pekilo flavor was observable in breads already at 2 % flour substitution level. The results obtained with hard and soft rye bread followed the same pattern. The textural parameters of sausages in which meat was substituted by conveyor dried Pekilo biomass indicated that Pekilo can, in combination with meat, form structures typical of sausages. For the best possible results however the water and fat content of the sausage mixture should be optimized. In organoleptic analysis the Pekilo flavor observed in sausages was not unanimously considered to be a negative factor. Partial substitution of ground meat with conveyor dried Pekilo in meat balls resulted in a distinct off-flavor and softer texture than that of control.

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September 12, 1978

PEKILO IN FINNISH FEED INDUSTRY

Feed Industry in Finland

The first feed factories in our country started their activities approx. 50 years ago. In the beginning, they manufactured compounds to be used as additional feed for poultry and fur animals. The quantities and the assortment were comparatively modest in the 1930's and 40's. Not until the 1950's did the feeding of domestic animals gain more exact and scientific attention. During the next decade, the number of compounds increased many times over. At the moment, tens of different products for all domestic animals are manufactured by feed industry.

The following quantities were manufactured during the last ten years:

year	1000 tons
1965	345
1970	603
1972	676
1974	869
1976	872
1977	718

In twenty years, from 1955 to 1975, industrial manufacture of feed compounds increased nearly tenfold. In 1976, the quantity of compounds manufactured was bigger than ever before, i.e. 872.000 tons. Last year, total manufacture dropped by some 17 %. The trend this year gives every indication of a new record again.

Industrially made feed compounds are approx. 20 % of the total quantity of feed consumed in our country. The share of feed compounds in feeding the main kinds of domestic animals is as follows:

	per cent of net energy of feed
poultry	ca 50
swine	ca 35
cattle	ca 10

The consumption of feed compounds in Finland and other Northern Countries in 1976:

	Denmark	Norway	Sweden	Finland
Poultry	38	figure not available	figure not available	24
Swine	156	491	330	229
Cattle	515	757	421	181

The manufacture of feed compounds for poultry will not increase in the near future, whereas the quantity of feed compounds for swine is going to increase.

The share of industrially made feed compounds for cattle has in our country not yet reached the level of many other countries. So we expect the demand for feed compounds for cattle to grow vigorously in the future.

The seven companies manufacturing feed compounds in our country have thirteen feed mills all over the country. Additionally, there are some small local mixing plants. The assortment of most of the manufacturers is considerably wide, containing feed compounds for all groups of domestic animals.

In 1977, the following quantities of various raw materials were used in feed compounds manufactured in Finland:

	1000 tons	per cent
Feed grain (barley, oats, wheat)	366,0	50,1
Protein raw materials (fish meal, soya, sunflower, rape, coconut, meat bone meal, yeasts, milk and whey powder, peas)	148,4	20,7
Industrial by-products (mill, meat processing, brewery, sugar and starch industries)	123,6	15,8
Mineral raw materials	46,4	6,5
Other raw materials	33,6	
	718,0	100,0

Finland is 80 % self-sufficient in raw materials. Quantitatively, the most important raw materials imported are fish meal and soya.

Pekilo in Finnish Feed Industry

The first truckload of Pekilo protein was delivered to a feed mill on 5th December 1975. Before this, Pekilo had already had a long history:

- In early 1960's Oy Keskuslaboratorio (the Central Laboratory of Wood Industry) started a protein project the goal of which was to choose the microorganisms suitable for protein production from among 300 or so microfungi.

- In 1968, eight companies formed the SITU group, the task of which was to develop a method of using spent sulfite liquor in protein production. In the same year, the first experiments on rats were carried out. Thereby, both chemical analysis and definitions of nutritional biological value and eventual poisonous qualities were made.

- In 1971, the Agricultural Research Centre made feeding experiments on swine, calves, broilers and laying hens.

- On the basis of expositions given, the State Institute of Agricultural Chemistry accepted the use of Pekilo as feed.

- About a year later, in November 1972, a decision was made to build a Pekilo factory in Jämsänkoski. The developing and delivering of the machinery was given to Tampella.

- The Pekilo plant was taken into use in 1975. The annual production of the plant was planned to be 10.000 tons Pekilo protein.

What was said above was in broad outline the process that gave Finnish feed industry a new raw material, i.e. Pekilo protein. This was a typical process from the point of view of feed industry. Every new raw material has to pass a similar process: "finding" the raw material; several chemical and physiological laboratory tests; extensive experiments on animals; approval by the State Institute of Agricultural Chemistry; starting mass production.

After getting enough experience of the technical suitability of Pekilo to the process used in feed industry, a delivery contract was undersigned between Yhtyneet Paperitehtaat (United Paper Mills Ltd) and the seven feed manufacturers. According to the contract, Yhtyneet delivers all of its Pekilo production to the feed mills every year.

The Meaning of Pekilo for Finnish Feed Industry

The aim of the feed manufacturers in our country is to use as much raw materials of native origin as possible, taking into account different spheres of interest at the same time. Pekilo contributes to this aim.

The sudden and heavy increases in the prices of protein raw materials in 1973 and 74 made the native alternatives more profitable. The quotas for soya and fish meal imports are yearly fixed by the state. In the 1970's, and especially in the last few years, the quotas for protein imports have been rather small compared with the demand. Pekilo secures feed industry the ability to manufacture productive feed compounds. Industrially made feed compounds are essential in intensive feeding of domestic animals in Finland.

Feed industry has also undertaken the task of using the diminishing quantity of protein raw materials in a way that guarantees all domestic animals the amount of proteins they need, at the same time taking into account that expensive proteins the availability of which is limited are not unnecessarily wasted in feeding of animals. In this respect, too, Pekilo contributes in a valuable way especially to the feeding of monogastric animals.

Making good use of the new many-sided Pekilo protein is possible only with the help of feed factories.

Quantities used

Feed industry has annually used the following amounts of Pekilo:

	tons
1975	240
1976	2.700
1977	2.100

The total amount this year will probably be much bigger than last year.

Quantities used in various products:

Feed compounds for poultry and swine:

All-feed	3 %
Half-concentrate	6 %
Concentrate	9 %

Feed compounds for cattle:

Milk replacers

Pekilo has not been used in milk replacers, although the researches of the Agricultural Research Centre have given encouringing results. The reasons are:

- that the production of milk powder in Finland is bigger than the demand and a natural way to use the surplus is the use in milk replacers

- that the use of milk replacers is started when the calf is 4 days old. In the tests, the calves were 2-3 weeks old when feeding with a replacer containing Pekilo was started.

Feed for ruminants

Pekilo protein is too expensive in Finland to be used in feed compounds for grown-up ruminants.

Feed compounds for minks:

Pekilo has not yet been used in the manufacture of feed for minks.

Feed compounds for fish:

The demand for dry feed compounds for fish has increased in Finland year by year. This year, thousands of tons of dry industrial feed first of all for trout farms will be manufactured. In these compounds, Pekilo has not been used for the time being.

Why are the percentages of Pekilo used in feed industry considerably smaller than the quantities figured out in the researches?

In feeding tests on swine and poultry, Pekilo has mainly replaced soya and fish meal, and in milk replacers milk protein. In addition to these protein raw materials of high quality, feed industry has had no choice but to look for and take into use protein raw materials that in other respects are clearly of lower value. Such raw materials are, as mentioned in the beginning, for instance many kinds of oil plant (rape, coconut, sunflower), meat bone meal, feather meal and peas. The use of every protein raw material of lower biological value limits the possibilities to substitute high-quality animal proteins by Pekilo.

Secondly, Pekilo has not up till now been available to a higher degree than the percentages mentioned above.

Thirdly, the price of Pekilo has not, for the time being, been lower than that of other protein raw materials.

Pekilo in the production process of a feed mill

In the beginning, about 3 years ago, Pekilo was delivered ungranulated in the form of flakes. Specific gravity of Pekilo was no more than 120 kg/cbm. This caused a few problems in transport, receipt and storing To make the situation up, an agreement was made with the deliverers that the product would be granulated in connection with the manufacturing process.

Pekilo has been delivered in bulk. Granulated product has caused no problems either in transport or in the production lines of feed mills. It runs easily, makes no clots and is easy to store. The physical characteristics of Pekilo are very suitable to a raw material used in feed industry.

As a whole, the reactions towards the use of this new protein raw material of native origin have been positive. Agricultural publications, as well as public means of communication have made Pekilo well-known in our country. The estimation among people in feed industry is that Pekilo has come up to the expectations put upon it as a result of the research and development period in feeding-physiological respect. This has also been proved by experience in practice.

EXPERIENCES ON FEEDING PIGS WITH PEKILO

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First experiences concerning Pekilo were obtained at Swine Research Station during 1971, when first feeding tests were carried out. Since that time additional experiences using Pekilo as the pig feed have been obtained to some extent. The Pekilo product is marketed in Finland through feed industry in complete feeds and protein concentrates. Out of all meal diets Pekilo takes up only a very small portion, about 2 percent of total diet, thus no accurate results can be given on effect of Pekilo upon production results in the practical swine production. In this report I will mainly deal with feed experiments performed with the pigs, and feed industry will give their own report on the subject.

General background

Grain is the most important feed of the pigs in Finland. Most generally pigs are fed with diet, which contains from 80 to 85 percent of grain. Main portion of this grain is barley meal. Even at its best, the protein content of the barley meal is too low for the pigs. Digestibility of the crude protein is poor and amino acid composition is unsatisfactory. Even so 50 to 60 % of digestible crude protein of the feed comes from the grain. Generally deficiency of nitrogen substance and unbalance of amino acids is corrected with imported protein feeds such as soya bean meal, fish meal and with native skimmed milk powder.

While considering Pekilo as possible feed stuff in Finland, it was first to be determined, how inadequacy of barley feeding can be fulfilled with it. Conventional protein feeds such as skim milk powder and later on also soya bean meal and fish meal were taken on as control protein sources.

Experiment 1

First test was performed in 1971 with growing finishing pigs, between 20 to 90 kg live weight. (Alaviuhkola et. al. 1975). Barley meal served as a basic feed and skim milk powder as control protein feed, which was replaced on digestible crude protein basis of 33, 66 and with 100 percent Pekilo. Digestibility for Pekilo crude protein was estimated as being 90 %. Feed allowance is shown in table 1. It was quite difficult to keep up with the feeding plan, as the Pekilo-feed was received in small quantities and its quality, protein content for example, differed quite a lot. At that time Pekilo was still produced under the laboratory scale.

Average composition of Pekilo and contents of most important amino acids are shown in table 2. Pekilo proved to be very appetizing to the pigs, even though the feed allowance used in the experiment, was strictly limited, especially at the finishing stage of the feeding ("high - low standards"). No side-effects were noticed during the experiment. Live weight gain, feed conversion efficiency and carcass quality of animals was the same with all groups, as shown in table 3.

The following digestibility coefficients were obtained in the digestibility experiment:

- organic matter	81
- crude protein	87
- crude fat	76
- nitrogen free extracts	84

Coefficients differ, especially with crude protein and crude fat, when comparing to the figures given by BRENNE £1976).

Experiment 2

Another feeding experiment with growing finishing pigs was performed in 1977 (PARTANEN 1978). Pekilo used in the experiment was normal mill produced product. Total of 96 high quality pigs were devided into four feeding groups, which were comparable in initial weight, sex and genetic pattern. The animals were fed in groups of four at the trough feeding. Soya bean meal and fish meal (75 - 25) in the control feed were partly or totally replaced by Pekilo. Chemical composition of feeds is shown in table 4. One mixture was used through the whole experiment, digestible crude protein level (130 g/kg) of which was known to be sufficient to the tested pig quality according to previous experiments.

Results (table 5) of daily gain and feed conversion show that while increasing Pekilo, the results somewhat, but not significantly, got poorer. No differencies were noted in the carcass quality between groups. Only loss at slaughter was greater among the animals receiving just barley meal and Pekilo than on others ($P < 0.5$). Changes were same with both sexes while increasing Pekilo (split-sex feeding was used).

Slightly higher standards were used in the experiment 2 than in first. Loss of appetite appeared to some extent in all groups, especially at the end of the trial. Daily feed intake of group IV was slightly lower than others, which partly explains their slower growth.

One of the reasons for slightly poorer production results of Pekilo group animals could be unfavourable amino acid content of feed protein. The following combination shows calculated lysine, as well as methionine + cystine contents of different experimental diets:

Diet	I	II	III	IV
Pekilo %	-	5	10	15
Soya bean meal/fish meal (3/4 - 1/4) %	14	10	5	-
Total lysine g/kg	8,7	8,9	8,7	8,6
" methionine + cystine g/kg	4,4	4,2	3,9	3,6
" (lysine = 100)	50	48	44	41

Figures show that, the methionine + cystine contents are below recommended standards (ARC, 1967) especially in the mixes containing Pekilo, and ratio of amino acids is not ideal. Possibly the results would have been better with additional methionine, possibly not. Our own experiments by supplementing the protein of soya bean meal and pea with methionine did not bring positive results. However, the methionine supplements on other SCP-products have brought improvement in the experiments both in daily gain and feed intake. (NIELSEN et al., 1974).

As a conclusion concerning growing finishing pig experiments with Pekilo in Finland, it can be mentioned that Pekilo has proved to be appetizing, well digestible feed, which can very well compensate conventional protein feeds as far as 2/3 of digestible crude proteins without deteriorating production results. This is valid when the barley meal is used as a basic feed. The commercial maximum hardly ever can reach 15 % inclusion level of Pekilo

Long period Pekilo experiment

The growing finishing pigs, which produce lean meat in shortest possible time, are best suitable for testing quality of the protein. Duration time of the experiment is, however, only about 100 days, thus all side-effects cannot be clarified. Also demands concerning protein in production of milk and embryos are somewhat different than in production of the lean meat. Thus during last year small scale experiment concerning effects of Pekilo on reproductivity of sows was started at the Swine Research Station. Mostly we will try to determine, whether the feed containing a lot of Pekilo, has possibly some toxic effects.

In this experiment eight (8) gilts will be fed with the barley meal diet by using Pekilo as a sole protein feed. The diet, which will be used up till farrowing, contains 13 % of Pekilo. Same quantity of litter mates will be fed with the diet containing soya bean meal and fish meal.

If possible, during mating, the same boar will be used on the litter mates. Feeds during the lactation period are almost same as during gestation period.

The protein contents of feeds are only slightly higher. The pigs (lots) are weaned at the age of five weeks and they are fed before weaning and three weeks after, with the same diet as the sows. The Pekilo group animals will not receive at any stage any other feed than Pekilo and barley meal (+ min. + vit. additives). This experiment will be continued under same condition during three generations.

There are some deficiencies in experiment plan. Experimental feed is totally vegetable diet. Amino acid unbalance has not been corrected, which as such might effect reproductive performance results (FOWLER et al., 1954). In addition amount of animals is quite small, thus for reaching conclusions concerning reproductive performance, cannot be accurately drawn. The main purpose of this test is however, to study if Pekilo has any harmful effects to the target animals causing abnormalities in development of litters. At this time (September 1978) the second generation is growing and reaching puberty. Nothing alarming has shown up. First farrowing results were the following:

Sow number	Number of alive pigs at birth:	
883 C	11	C = control gilt
880 P	9	P = litter mate, which has been fed with Pekilo
14 C	10	
20 P	9	
52 C	10	
43 P	4	
928 C	5	
931 P	9	
961 C	10	
959 P	8	
962 C	7	
964 P	3	
833 C	5	
835 P	9	
861 C	13	
857 P	-	(not pregnant)

There were some difficulties in detec ing signs of heat of some animals and this is apparently cause of some small litters. Farrowings were not watched, which is normal practise at the station.

Development of the litters was normal. No malformed pigs appeared in either group. Nine piglets, some of which died naturally during parturition and some were killed, were examined post mortem at the State Veterinary Medical Institute. The experiments did not indicate anything abnormal and deaths could not be connected to Pekilo-diet. The experiment is still unfinished, but results up today indicate that Pekilo can be quite usable also as the protein source of the sows.

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TABLE 1 - FEED ALLOWANCE PER PIG PER DAY [1] - EXPERIMENT 1

Weeks from 20 kg live-weight	Treatments									
	I		II			III			IV	
	Barley meal kg	Skim milk powder kg	Barley meal kg	Skim milk powder kg	Pekilo kg	Barley meal kg	Skim milk powder kg	Pekilo kg	Barley meal kg	Pekilo kg
1	0.6	0.3	0.65	0.2	0.08	0.7	0.1	0.16	0.75	0.24
2	0.8	"	0.85	"	"	0.9	"	"	0.95	"
3	1.0	"	1.05	"	"	1.1	"	"	1.15	"
4	1.25	"	1.30	"	"	1.35	"	"	1.40	"
5	1.45	"	1.50	"	"	1.55	"	"	1.60	"
6	1.65	"	1.70	"	"	1.75	"	"	1.80	"
7	1.85	"	1.90	"	"	1.95	"	"	2.00	"
8	2.00	"	2.05	"	"	2.10	"	"	2.15	"
9	2.20	"	2.25	"	"	2.30	"	"	2.35	"
10 -	2.40	"	2.45	"	"	2.50	"	"	2.55	"

1) Mineral + vitamin mixtures were added

TABLE 2 - AVERAGE CHEMICAL COMPOSITION OF THE FEEDS USED IN EXPERIMENT 1

Feed	Skim milk powder	Pekilo	Barley meal
Dry matter %	96,5	95.0	67.3
Org. matter % d.m.	91.8	94.4	97.2
Crude protein "	39.8	55.9	15.2
Ether extract. "	1.1	1.1	2.1
Crude fibre "	-	8.8	4.4
N.f.e. "	50.9	28.6	75.5
Ash "	8.2	5.6	2.8
Lysine g/16 g N	-	5.85	-
Methionine "	-	1.48	-
Cystine "	-	0.84	-
Cystathionine g/16 g N	-	0.32	-
Threonine	-	4.60	-

TABLE 3 - MEAN DAILY GAIN, FEED: GAIN RATIO AND CARCASS MEASUREMENTS OF PIGS GIVEN DIETS SUPPLEMENTED WITH DIFFERENT AMOUNTS OF SKIM MILK POWDER AND PEKILO (24 PIGS/TREATMENT FROM 20 TO 90 KG LIVE WEIGHT):

	Treatment			
	I	II	III	IV
Daily gain g/d	718	716	726	711
F.u. per pig per day	2.06	2.05	2.05	2.06
" per kg gain	2.87	2.87	2.82	2.90
Thickness of back fat mm	26.6	27.2	26.7	27.4
Firmness " " " points (9-15)	12.7	12.5	12.0	12.3
Meat colour points (1-5)	2.85	2.92	3.05	2.92
Meat + bone in valuable cuts %	74.7	74.1	74.1	73.7

TABLE 4 - CHEMICAL COMPOSITION OF FEEDS USED IN EXPERIMENT 2

Feed	Barley meal	Soya bean meal	Herring meal	Pekilo
Dry matter %	87.2	87.6	92.7	95.3
Crude prot. %	10.3	45.2	69.1	49.1
Ether extract %	1.8	1.8	8.4	1.1
N.f.e. %	68.0	30.1	-	33.8
Crude fibre %	4.8	4.9	-	5.7
Ash %	2.3	5.6	12.0	5.6
Lysine g/kg	-	28.9	50.1	31.8
Met. + cyst. g/kg	-	10.7	29.8	9.1
Threonine "	-	18.9	33.6	23.9

TABLE 5 - MEAN DAILY GAIN, FEED: GAIN RATIO AND CARCASS QUALITY OF PIGS GIVEN DIETS SUPPLEMENTED WITH SOYA BEAN MEAL, HERRING MEAL OR PEKILO
(24 PIGS/TREATMENT FROM 22 TO 90 KG LIVE WEIGHT)

	Treatment			
	I	II	III	IV
Daily gain g/d	691	692	679	651
" ratio	100	100	98	94
Feed consumption				
- f.u. per pig/d	2.00	2.02	1.99	1.97
- f.u./kg gain	2.90	2.92	2.93	3.02
Thickness of back fat mm	21.1	21.5	20.2	21.1
Meat colour (refledtom.	37	37	35	38
Meat + bone in valuable cuts %	81.6	81.4	82.2	81.5

OPTIMAL STANDARDS FOR COMPENSATING ANIMAL PROTEIN WITH PEKILO-PROTEIN IN FEEDING OF EARLY WEANED PIGS

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Soviet Union

Great attention is paid in the Soviet Union as well as in other countries to adequate feeding of the domestic animals. As regards quantity and quality of protein it is utmost important to determine the optimal value of the protein portion in the feed mixture. One of the greatest difficulties in satisfaction of protein requirements, is the standard feeding of pigs and poultry, because these animals require adequate animal proteins in order to grow and develop. When the fact that cultivation area of the vegetables containing great amounts of protein is limited, and production of the fish meal is decreasing, taking advantage of using the products of micro biological industry is inevitable. These products are produced by cultivating bacteria, yeasts and fungi on different substrates.

Our country has the far developed oil-, chemical, pulp- and food industry, which in addition to its primary products also produces feed yeast and other substances containing plenty of protein for feed industry. Still we were interested to test both scientifically and in practice the new protein, which Finnish scientists had developed first in the laboratory of the pulp- and paper industry and which is now produced in the process line of the pulp mill.

The experiments published in this report were performed by Agricultural Institute of Don at the pig farm of Ust-Don area and in Aleksejevska poultry breeding station.
These experiments are part of the scientific technical exchange program between Finland and Soviet Union covering agriculture.
Purpose of the experiment was to investigate the effect of different Pekilo-quantities in pig feeds.

Five groups of pigs weaned at the age of two months were formed for the experiment. The first group had 27 and all others had 28 pigs. The pigs

were growed in groups. The standards, set by the Soviet Union Cattle Breeding Institute, were used.

Duration of the experiment was 60 days, during this time animals were fed the feed mixtures, in which skim milk was compensated stage by stage with the Pekilo. The portions of Pekilo from supplemental protein were 0, 25, 50, 75 and 100 %. Composition and nutrient contents of the feeds are presented in the table 2. Data of feed consumption and growth of the animals are in the table 2.

Average daily gain was greatest among the pigs of group 3. These pigs had as protein supplement 50 % of Pekilo. Group 1 was the second. In this group dried skim milk was used as an supplemental protein.

The table also shows, that feed consumption was less with three first groups than with groups 4 and 5, which were using 75 and 100 % Pekilo from the supplemental protein.

Conclusion

The experiment performed on quite large number of early weaned pigs show, that part of the animal protein can be compensated with Pekilo-protein. In the experiments performed 50 % of supplemental protein was proved to be best. Exceeding of this amount did not give good results in this age group.

Table 1. Composition (%) and nutritive value of experimental diets.

	Groups									
	1		2		3		4		5	
Age, months	2-3	3-4	2-3	3-4	2-3	3-4	2-3	3-4	2-3	3-4
Wheat meal	19,5	11,8	19,2	11,7	19,1	11,6	18,8	11,5	18,6	11,3
Barley meal	54,8	65,3	63,9	64,4	53,5	63,6	52,7	63,3	51,9	62,2
Alfalfa meal	7,8	9,2	7,7	8,8	7,6	8,7	7,5	8,6	7,4	8,5
Salt	1,2	1,1	1,1	1,1	1,1	1,1	1,1	1,1	1,1	1,1
Dried skim milk	15,5	11,8	10,8	8,2	6,9	5,8	3,8	2,9	-	-
Pekilo	-	-	6,2	4,7	10,8	8,1	15,1	11,5	20,0	15,8
Chalk meal	1,1	0,8	1,1	1,1	1,0	1,1	1,0	1,1	1,0	1,1
	100	100	100	100	100	100	100	100	100	100
In dry matter:										
Feed units/kg	1,3	1,8	1,3	1,8	1,3	1,8	1,3	1,68	1,3	
Digestible protein, g	200	165	200	165	200	165	200	165	200	165
Digestible protein g/feed unit[x)]	117		117		117		117		117	
Salt, g	19	15	19	15	19	15	19	15	19	15
Calcium, g	14	9	14	9	14	9	14	9	14	9
Phosphorus, g	9	7	9	7	9	7	9	7	9	7
Carotine, mg	23	16	23	16	23	16	23	16	23	16

x)- oat unit

Table 2. Body weight gain and feed intake of pigs.

	Groups				
	1	2	3	4	5
Number of animals	27	28	28	28	28
Number of feeding days	1620	1680	1680	1680	1680
Average body weight in the beginning (2 months) ± SD	18,2±0,24	18,7±0,28	18,4±0,28	18,4±0,28	18,6±0,28
Average live weight in the end (4 months) ± SD	46,0±1,0	45,2±1,02	46,4±0,94	42,3±0,89	43,2±1,029
Total weight gain, kg	751	744	795	670	690
Average daily gain, g ± SD	464±14,43	443±17,95	473±8,57	398±17,11	411±12,47
Total feed consumption, feed units[x)]	3402	3528	3528	3528	3528
Feed conversion, feed units/kg gain	4,52	4,74	4,43	5,26	5,11

x)- oat unit

EFFICIENCY OF USING PEKILO-PROTEIN IN FEEDING OF EARLY WEANED PIGS

Bobrov, E.P., Chikov, A.E. and Zhernovoj, I.T.

In order to reduce the global protein shortage, the mills have been built for producing the single cell proteins such as hydrolyze- and paraffin yeasts. According to the articles published by many researchers, one of such products is Pekilo-protein, technology of which has been developed by the Finnish Pulp & Paper Research Institute. Tampella has generously provided us with Pekilo test lots to be tested by our institute.

We started investigation by testing Pekilo in the feed mixtures of pigs. The pigs were weaned at the age of 20 days, having an average weight of 5.2 to 5.3 kg.
Composition and nutrient content of the feed mixtures used in this experiment are presented in the table 1.

As the values in the table show, the aim of this test was to compare nutrient value of Pekilo against feed yeast by mixing it into the feed mixtures, which contained animal protein (casein and fishmeal) or only soyabean meal as supplemental protein.

The primary results of the test are presented in the table 2. The values in the table clarify that during the first period, the pigs which were fed with the Pekilo growed faster than pigs fed with feed yeast, in the case, when the mixture contained animal protein.

Weight gain of the animals in groups 3 and 4, which did not receive animal protein, were same while feeding with either yeast or Pekilo.

In the second phase of the experiment the control group slightly passed

the pigs in the second group in growth. Difference is probably, statistically insignificant.

Conclusion

According to average daily weight gain of the pigs during whole experiment, it can be assumed that the feed yeasts and Pekilo are just as good in productivity effect and they can be used within same quantity as well as together with animal proteins and in the corn- and soya based feed mixtures without damaging growth, development or health conditions of pigs.

Pekilo-protein did not change the physiological or biological characteristics of blood, during the period, when this feed component was used.

Table 1. Composition of experimental diets.

	Age							
	20-40 days				41-60 days			
Group	1 control	2 exp.	3 control	4 exp.	1 control	2 exp.	3 control	4 exp.
Caseine	3,00	3,00	-	-	-	-	-	-
Fish meal	6,00	6,00	-	-	6,00	6,00	-	-
Soyabean meal	15,50	15,50	27,20	27,20	11,0	11,0	17,30	17,30
Yeast	11,00	-	11,00	-	14,00	-	14,00	-
Pekilo	-	11,00	-	11,00	-	14,00	-	14,00
Corn meal	51,00	51,00	44,27	44,27	62,50	62,5	58,54	58,39
Fat	6,2	6,20	8,80	4,60	4,6	6,80	6,80	6,80
Sugar	5,0	5,00	5,00	5,00	-	-	-	-
Vitamin premix	1,0	1,00	1,00	1,00	1,0	1,00	1,00	1,00
Chalk meal	0,45	0,45	0,96	0,96	0,40	0,85	0,85	0,85
Phosphate	0,35	0,35	1,19	1,19	-	-	0,85	0,85
Methionine	0,10	0,10	0,18	0,18	0,10	0,10	0,16	0,16
Salt	0,40	0,40	0,40	0,40	0,40	0,40	0,50	0,50
Calculated analysis per kg:								
Feed units	1,35	1,35	1,38	1,38	1,30	1,30	1,35	1,35
ME kcal	3598	3600	3599	3600	3574	3574	3583	3583
Crude protein, g	239,1	238,00	239,8	239,80	219,8	219,8	220,7	220,7
Lysine, g	15,52	15,52	15,57	15,57	13,82	13,82	13,80	13,80
Methionine+ cystine, g	8,80	8,80	8,78	8,78	8,07	8,07	7,96	7,96
Tryptofane, g	3,09	3,09	3,01	3,01	2,72	2,72	2,57	2,57
Calcium, g	9,02	9,02	9,07	9,07	8,11	8,11	8,04	8,04
Phosphorus, g	7,03	7,03	6,98	6,98	6,52	6,52	6,54	6,54

Table 2. The most important results of the experiment.

	Group			
	1	2	3	4
Number of pigs	24	24	24	24
Body weight, kg				
age 20 days	5,29	5,28	5,28	5,32
" 40 "	8,54	9,84	9,84	9,82
" 60 "	16,87	18,03	18,74	18,63
Average daily weight gain, g				
20-40 days	154,76	216,78	217,31	213,83
40-60 "	416,60	409,31	444,54	441,00
20-60 "	289,54	318,52	336,36	332,61
Feed intake, kg				
20-40 days	0,390	0,406	0,405	0,424
40-60 "	1,030	1,020	1,030	1,070
20-60 "	0,712	0,712	0,717	0,748
Feed conversion				
kg/kg gain	2,46	2,24	2,28	2,25
feed units/kg gain	3,31	2,41	2,45	2,61
crude protein/				
g/kg gain	554	502	482	508

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NUTRITIONAL EXPERIENCES ON FEEDING PIGS WITH THE PEKILO

(EVALUATING PEKILO AS A PROTEIN SUPPLEMENT IN FEED MIXTURES FOR GROWING-FINISHING PIGS)

The experiments with PEKILO in Norway have mainly included studies concerned with the effect of replacing extracted soybean meal by PEKILO as a protein source in practical feed mixtures for growing finishing pigs. In 1974 the first experiment was carried out in cooperation between the departments of animal nutrition at the Veterinary College in Oslo and the Agricultural University at Ås. Since 1975 the PEKILO-experiments were incorporated in a research programme established by the Norwegian Agricultural Research Council with the working title "Single Cell Protein as feed for livestock". Within the framework of this programme, nutritional evaluations were carried out in the projects "Untraditional feeds" (1975-76) and "Untraditional protein feeds" (1977-79).

The presentation of experimental results at this symposium must be considered preliminary because some of the experimental work is still going on. This paper should therefore be regarded as a progress report rather than a scientific paper. However, the main conclusions will probably hold true in the final papers. The experiments and studies have been separated into five sections:

1. Chemical composition and nutrient contents
2. Digestibility and biological value of nutrients
3. Growth experiments comparing extracted soybean meal and PEKILO as protein supplement for growing finishing pigs
4. PEKILO as protein supplement combined with cereals in diets for growing finishing pigs
5. Quality of meat and fat in pigs fed diets with PEKILO

CHEMICAL COMPOSITION

Three different batches of PEKILO have been used in the experiments at the Department of Animal Nutrition; one in 1974, one in 1975, and the last one in 1976.

Table 1. Nutrient contents in three batches of PEKILO

Batch no.	PEKILO 1	PEKILO 2	PEKILO 3
Number of analyses	1	2	3
Dry matter, %	90.1	92.5	90.5
Ash, %	5.5	6.8	5.0
Ether extract, "	0.3	3.0	1.8
Crude fiber, "	8.9	9.0	5.7
Crude protein, "	41.4	46.3	39.7
NFE, "	34.0	27.4	38.3
Crude fat,[2] "	-	6.6	4.4
True protein,[3] "	-	41.1[1]	37.4[1]

[1] One analysis [2] After HCI-treatment. [3] Crude protein minus amides

Table 2. Content of macro- and microminerals in two batches of PEKILO

Batch no.	PEKILO 2	PEKILO 3
Phosphorus, g/kg	18.0	11.6
Calcium, "	5.8	3.0
Potassium, "	4.3	8.1
Sodium, "	0.3	0.2
Chlorine, "	0.3	0.2
Magnesium, "	0.8	0.8
Iron, mg/kg	197	112
Copper, mg/kg	1.8	2.2
Manganese, mg/kg	93	67
Zinc, mg/kg	93	117

Table 3. Amino acid content of three batches of PEKILO, g amino acid/16 g N

Batch no.	PEKILO 1	PEKILO 2	PEKILO 3	Average of 3 batches
Number of analyses	1	1	4	6
Alanine	5.71	6.14	6.21	6.11
Valine	4.72	4.78	4.85	4.82
Glycine	4.57	4.41	4.61	4.56
Iso-leucine	3.71	4.12	4.20	4.10
Leucine	6.37	6.52	6.69	6.61
Proline	3.88	3.64	3.83	3.80
Threonine	4.03	4.09	4.13	4.11
Serine	4.06	4.16	4.43	4.32
Methionine	1.73	1.45	1.56	1.57
Phenylalanine	3.51	3.77	3.64	3.64
Asparginic acid	7.01	7.85	7.69	7.60
Glutaminic acid	9.62	10.97	10.65	10.53
Tyrosine	3.12	2.99	3.24	3.17
Lysine	6.03	6.20	6.13	6.13
Histidine	3.61	2.03	3.09	3.00
Arginine	5.33	5.90	6.21	6.01
Cystine	1.15	1.15	-	1.15

Hydroxyproline and Tryptophane were not determined

The content of nucleic acids was not determined, but BRENNE (1976) reports the figure to be 9-10%. The protein content given as Kjeldahl-N x 6.25 varies distinctly from batch to batch. Also the other nutrients vary. Some of the variations may be explained as analytical errors, but there is more likely a true difference between batches. The composition of the PEKILO-protein, however, shows that stability and discrepancies are probably occasional, analytical variations.

DIGESTIBILITY AND BIOLOGICAL VALUE

Experiments for determining digestibility were carried out at the Veterinary College in 1973 and 1974 (BRENNE 1976) and at the Department of Animal Nutrition (Ås) in 1974 (PEKILO 1). Balance trials were carried out at Ås in 1977 (PEKILO 3).

Table 4. Digestibility of nutrients in PEKILO, in experiments with pig.

	PEKILO 0[1]	PEKILO 1[2]	Assessed Practical values
Number of determinations	4	3	
Digestibility coefficients of:			
Organic matter	82	69	-
Crude protein	78	95	85
Crude fat [3]	20	-	20
Crude fiber	78	57	60
Nitrogen-free extract	98	55	75

[1] BRENNE 1976 [2] LYSØ 1975 [3] Chloroform/metanol-extraction

The values found in 1974 and 1975 differ markedly. This is thought to be a s result of experimental techniques. The principle of difference is used in both experiments. BRENNE (1976) used tapioca meal as the only basic feed while LYSØ (1975) used barley and tapioca as basis feed (50% of each).

As an overall judgement, the protein digestibility of PEKILO protein should be set to 85.

Furthermore, it is not quite clear what kind of fat-analyses should be used. The ordinary ether-extract method gives distinctly lower values than the procedure that includes treatment with mineral acid (HCl). It is therefore difficult to determine coefficients for fat digestibility, and for the time being figures will be rather unreliable.

A set of practical values for digestibility of nutrients is included in Table 4, and in Table 5 these values are used for calculating DE, ME and NEF_S. The calculations are based on the ROSTOCK-equations (SCHIEMANN et al. 1971). The content of Scandinavian feed fattening units is also given in table 5.

Table 5. Calculated energy content of PEKILO in pig diets

	PEKILO 1	PEKILO 2	PEKILO 3
Digestible energy, DE, Mcal/kg	3.31	3.41	3.30
Metabolizable energy, ME, Mcal/kg	2.99	3.05	3.01
" " ; MJ/kg	12.50	12.75	12.58
Net energy, NEFs, Mcal/kg	1.82	1.83	1.85
FU (feed fattening units) per 100 kg	87	88	88

The biological value was determined using pigs of 25-50 kg lw. and modified THOMAS-MITCHELL method with 10% crude protein in the feed; approx. 90% of this protein was derived from PEKILO (PEKILO 3). The values are given in table 6 together with values of fishmeal and soybean meal.

Table 6. True digestibility (TD), biological value (BV) and net protein utilization (NPU) of PEKILO in experiments with pigs 25-50 kg wt.

	PEKILO 3	FISHMEAL[1)]	SOYBEAN MEAL[1)]
True digestibility, TD	78.5	96.6	90.7
Biological value, BV	75.1	77.1	62.0
Net protein utilization, NPU	59.0	74.4	56.2

[1)] Determined with rats by EGGUM (1968)

The PEKILO protein has a low true digestibility (TD), but a high biological value (BV) and a net protein utilization (NPU) which is similar to soybeanmeal.

PEKILO REPLACING SOYBEAN MEAL AS A PROTEIN SUPPLEMENT FOR GROWING FINISHING PIGS

For the time being the role of PEKILO in pig nutrition seems to be a question of either partial or total replacement of soybean meal by PEKILO. In Norway, for several reasons, the comparison of PEKILO and soybean meal was carried out on a crude protein basis. There were several reasons for this. All the time the experiments were carried out, the digestibility of PEKILO protein was not known and it was also of interest to study the quality of PEKILO protein in ordinary rations without special adjustments.

The results of these experiments with growing finishing pigs are given in table 7.

Table 7. The effect of replacing extracted soybean meal by PEKILO in the feed for growing finishing pigs 25-100 kg lw.

Protein supplement	100% soya 0% PEKILO	50% soya 50% PEKILO	0% soya 100% PEKILO
Experiment 1 (BRENNE 1976)			
Number of animals	16	14	15
Daily gain 25-100 kg, g[1)]	655	646	651
FU/kg gain[1)]	3.20	3.24	3.28
Backfat thickness, mm [2)]	21.8	22.5	22.0
Fat in % of lean in back cross section	76.9	81.3	73.6
Experiment 2 (HANSSEN 1978)			
Number of animals	14	14	14
Daily gain 25-100 kg, g[1)]	662	670	671
FU/kg gain[1)]	3.28	3.24	3.25
Backfat thickness, mm [2)]	22.0	21.9	21.3
Fat in % of lean in back cross section	65.1	60.0	61.4
Experiment 3 (HANSSEN 1978)			
Number of animals	15	16	16
Daily gain 25-100 kg, g[1)]	699	707	698
FU/kg gain[1)]	3.11	3.11	3.20
Backfat thickness, mm [2)]	20.3	19.9	19.6
Fat in % of lean in back cross section	61.7	59.1	59.7

[1)] Corrected to 73% carcass weight

[2)] Average of fat thickness measured at shoulder, middle of back and rump

No effects were noticed on growth rate, FCE and carcass quality when soybean protein was replaced by 50% and 100% PEKILO protein.

Corrections were not made for the content of nucleic acids and amino acids when calculating the rations. The experiments indicate, however, that it is possible to replace soybean meal by PEKILO as far as crude protein content is considered.

The question then remains as to how much PEKILO should be used in the ration. This depends mainly on what should be regarded as adequate amino acid content especially because of the low methionine content of Single Cell Proteins in general.

A ceral ration with PEKILO as the only protein supplement was used in two experiments in order to study the effect of adding methionine and lysine to a practical feed mixture. The experimental design and the results are given in Table 8. The ceraelas used were barley and sorghum.

The results showed no effect of adding DL-methionine to the ration. Growth rate and FCE were improved when adding 0.1% HCl-lysine (0.8% lysine in ration), but no further improvement occurred when adding another 0.1% HCl-lysine (0.9% HCl-lysine in ration).

Table 8. The effect of adding HCl-lysine and DL-methionine to a ration of cereals and PEKILO fed to growing-finishing pigs 25-100 kg lw.

% crude protein	16.5	16.5	16.5	16.5	16.5
% cereal protein	57	57	57	57	57
% PEKILO protein	43	43	43	43	43
% lysine in ration	0.7	0.8	0.9	-	-
% methionine + cystine in ration	-	-	-	0.52	0.57
Experiment I					
Number of pigs	16	15	15	22	24
Daily gain, g[1]	699***	759***	768***	741	741
FCE, kg feed/kg gain[1]	3.06	2.85	2.83	2.90	2.93
Backfat thickness, mm[2]	18.5	18.5	18.7	18.1	19.1
Fat in % of lean in back cross section	52.9	48.9	49.3	47.5	53.1
Experiment II					
Number of pigs	14	12	14	21	19
Daily gain, g[1]	733	756	751	744	748
FCE, kg feed/kg gain[1]	2.99	2.90	2.96	2.95	2.96
Backfat thickness, mm[2]	19.1	20.7	19.9	19.9	19.9
Fat in % of lean in back cross section	56.8	61.5	55.3	57.6	57.7

[1] Corrected to 73% carcass weight

[2] Average of fat thickness measured at shoulder, middle of back and rump

++ P < 0.01 [3] Calculated

+++ P < 0.001

The experiments comparing soybean meal and PEKILO, and the experiments where amino acids are added, show that PEKILO may replace soybean meal as protein supplement in pig feeding. PEKILO seems well suited for use in combination with cereals such as barley and sorghum in practical feed mixtures. The amino acid content of the ration should be on the recommended level of 0.8% lysine and 0.57% methionine + cystine in the period 25-100 kg lw.

QUALITY OF MEAT AND FAT IN PIGS FED DIETS WITH PEKILO

Energy sources of industrial and petrochemical origin for production of bioprotein make it necessary to examine the quality of products from animals that are fed bioproteins. Because of the consumers' emotional attitude to animal products with connections to industrial wastes and petroleum, any relationships between energy sources and the final product became an important question. It is a matter of adherent substances giving strange tastes and odours. It is also a matter of storing quality to avoid fat rancidity.

To study the influence of PEKILO on the product, analyses of fatty acid pattern, AOM and TBA were carried out, and a well experienced test panel judged fat and meat organoleptically. The results are given in table 9. The quality of fat and meat was good in these experiments and did not indicate special negative effets from feeding PEKILO to growing finishing pigs.

Table 9. Data from quality studies of fat and meat from growing finishing pigs fed PEKILO

PEKILO in % of feed	0	8.9	18.0
Experiment I			
Number of animals	7	7	7
Organoleptic scores, meat[1)]	7.8	8.2	8.2
Organoleptic scores, fat [1)]	7.7	7.7	7.2
Saturated fatty acids, %	48.5*	46.1*	46.2*
Unsaturated fatty acids, %	51.5*	53.9*	53.8*
TBA[2)]	129	139	164
AOM[3)]	3.5	4.4*	3.6
Experiment II			
Number of animals	7	8	8
Organoleptic scores, meat[1)]	7.7	7.8	7.8
Organoleptic scores, fat [1)]	8.3	8.2	8.3
TBA[2)]	152	150	143

* $P < 0.05$

1) 10 = very good, 8 = quite good, 6 = good (normal)
4 = less good, 2 = not good (bad)

2) TBA = Thiobarbituric acid score. Indicates amount of aldehydes in fat. <50 = very good, 220 - limit for using fresh fat in smoked sausage

3) AOM = Active oxygen method. Indicates amount of peroxide in fat. Increasing scores by increasing quality (scores = time in hours to reach a certain peroxide level).

SUMMARY AND CONCLUSIONS

The work of evaluating the nutritive value of PEKILO for pigs in Norway has been carried out at the Department of Animal Husbandry and Genetics at the Norwegian Veterinary College and at the Department of Animal Nutrition at the Agricultural University of Norway. The main part of the work is financed by grants from the Norwegian Agricultural Research Council and for some time also coordinated by a working group appointed by the Council.

The work has been divided into five smaller sections as listed below. Tables showing the experimental results are referred to and main conclusions are given.

1. Chemical composition (Tables 1-3)
2. Digestibility of nutrients etc. (Table 4-6)
3. PEKILO replacing soybean meal as protein supplement in feeding growing finishing pigs
   Conclusion: PEKILO may replace extracted soybean meal in cereal diets for growing finishing pigs on the basis of crude protein content (Kjeldahl-N x 6.25) (Table 7).
4. Effect of adding lysine and methionine to a diet of PEKILO and barley/sorghum fed to growing finishing pigs
   Conclusion: A diet of cereals (barley/sorghum) with PEKILO as the only protein supplement should be fortified with lysine in order to reach adequate protein quality (Table 8).
5. Quality of fat and meat in pigs fed diets with PEKILO
   Conclusion: The observations do not indicate any influence of PEKILO on fat and meat quality (Table 9).

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EXPERIENCES WITH THE PEKILO PROTEIN AS A PROTEIN SOURCE IN POULTRY FEEDING IN NORWAY

Introduction

The experiments with PEKILO in the feeding of poultry have been carried out at The Department of Animal Husbandry and Genetics (Veterinary College of Norway) and at The Department of Poultry and Fur Animal Science (Agricultural University of Norway). Some of the work was financed by grants from the Norwegian Agricultural Research Council.

The evaluation of PEKILO as a protein source in poultry feeding in Norway, may be devided into two main sections, namely:

1. Digestibility and biological value of PEKILO-protein, including amino acid availability and determination of metabolizable energy (ME) (BJØRNSTAD 1977)
2. PEKILO protein replacing soybean protein in diets for chickens and the effect of adding methionine and methionine substituents to diets with PEKILO (LAKSESVELA & SLAGSVOLD 1974, BRENNE 1976)

1. EVALUATING PEKILO IN LABORATORY EXPERIMENTS

Analyses of chemical composition and nutrient contents as the basis for a laboratory evaluation will not be considered here. This aspect is discussed in the report "NUTRITIONAL EXPERIENCES ON FEEDING PIGS WITH THE PEKILO".

Digestible crude protein (DCP)

Determination of protein digestibility was carried out in experiments with cholostomized laying hens. Protein digestibility was determined in diets with two different levels of PEKILO, providing 100% and 33% of the protein, respectively. Two batches of PEKILO were studied in these experiments.

Table 1. Apparent digestible crude protein of PEKILO in experiments with cholostomized laying hens (BJØRNSTAD 1977)

% PEKILO protein in experimental feed	PEKILO A	PEKILO B
33%	81.3	-
100%	67.7	74.1
100%[1)]	66.7	81.4

1) Corrected by regression

Digestibility and availability of amino acids

Amino acid digestibility was determined with cholostomized laying hens fed diets with PEKILO providing 100% of the protein and with chickens in experiments using the difference technique.

Table 2. Digestibility of some amino acids of PEKILO protein in experiments with cholostomized laying hens. (Digest. coeff. as average of a single determination on two different protein levels) (BJØRNSTAD 1977)

Amino acids	Digestibility coefficient	
	PEKILO	SOYBEAN MEAL
Isoleucine	82.0	88.0
Leucine	83.0	88.5
Methionine	77.5	87.3
Phenylalanine	84.6	91.1
Thyrosine	86.0	91.2
Valine	80.9	86.3
Lysine	87.5	92.5

Table 3. Apparent digestibility of some amino acids determined in different experiments with chickens (BJØRNSTAD 1977)

Amino acids	Digestibility coefficient	
	PEKILO	SOYBEAN MEAL
Isoleucine	87.8	81.5
Leucine	77.4	79.4
Methionine	87.4	87.0
Phenylalanine	75.7	84.8
Thyrosine	90.9	78.4
Valine	83.7	82.3
Lysine	90.0	87.8

Table 4. Available lysine determined in growth experiments with chickens at different lysine levels in feed (BJØRNSTAD 1977)

Lysine level, % of feed	Availability coefficient	
	PEKILO	SOYBEAN MEAL
0.66	78.5	> 100
0.76	99.7	> 100
0.86	85.1	87.4

Biological value

Biological value expressed by PER (Protein Efficient Ratio) has been determined in two experiments with chickens.

BJØRNSTAD (1977) reported negative growth in the PEKILO group and it was impossible to calculate a PER-value.

BRENNE (1976) showed positive PER-values in an experiment with four different batches of PEKILO. The PER-values of PEKILO were, however, significantly lower than the values of soybean meal.

Feed	PER-values
Soybean meal	1.58
PEKILO I	1.05
" II	0.95
" III	0.88
" IV	0.90

These result indicate that PEKILO providing all protein in the ration is inadequate for feeding chickens.

Metabolizable energy

ME was determined in difference experiments with chickens. The ME values are calculated in kcal/kg feed and adjusted to nitrogen-equilibrium.

Table 5. ME in kcal/kg feed adjusted to nitrogen-equilibrium (BJØRNSTAD 1977)

Feed	No. of determin.	% DM	ME_N, kcal/kg	ME in % of GE
Soybean meal	12	90.3	2353	55.0
PEKILO A	8	90.4	2350	51.4
PEKILO B	8	92.9	2210	47.3

2. PEKILO REPLACING SOYBEAN MEAL IN FEED FOR CHICKENS

The main question in evaluating PEKILO as a commercial protein source in poultry feeding, is most likely its ability to replace soybean meal in practical feed mixtures. The experimental work of BRENNE (1976) deals with this topic and with the aspect of adding extra methionine to the feed.

Table 6. The effect of replacing soybean meal by PEKILO in practical feed mixtures for chickens. 2 replicates (BRENNE 1976).

Protein source:				
PEKILO	0	5	10	15
Soybean meal	15	10	5	0
Herring meal	5	5	5	5
Final weight, relat. figures	96	94	92	90
RCR, relat. figures	103	109	112	113

Table 7. The effect of replacing soybean meal by PEKILO in practical feed mixtures for chickens. 3 replicates (BRENNE 1976)

Protein source:	% of feed							
PEKILO	0	3.1	6.2	9.3	12.4	15.5	18.6	24.8
Soybean meal	24.8	21.7	18.6	15.5	12.4	9.3	6.2	0
Final weight, rel.fig.	99	101	96	98	97	94	94	88
FCR, rel. fig.	101	100	102	103	104	106	110	111

The experiments showed decreasing growth rate and increasing FCR by replacing an increasing percentage of soybean meal by PEKILO. This effect was almost eliminated by adding 2 g DL-methionine and 1.5 g DL-methionine to the feed in the experiments in table 6 and 7, respectively. The effect of adding methionine to the ration is illustrated

in the regression equations calculated by BRENNE (1976).

1. The relationship between PEKILO protein in % of protein supplement (x) and final weight, relatively (y)
   a) DL-methionine not added:
      $y = 101.78 - 0.0807x$
   b 1.5 g DL-methionine added per kg feed
      $y = 101.78 - 0.0317\ x$

2. The relationship between PEKILO protein in % of protein supplement (x) and FCR, relatively (y)
   a) DL-methionine not added:
      $y = 101.96 + 0.1731\ x$
   b) 1.5 g DL-methionine added per kg feed
      $y = 06.01 + 0.05788\ x$

In a previous study LAKSESVELA & SLAGSVOLD (1974) showed a negative effect on growth rate by adding methionine, methionine substitutes and sulphur- containing substances to diets with PEKILO. The result emphasizes that care should be taken when fortifying feed mixtures with synthetic amino acids.

Table 8. Weight gain and feed conversion of chickens fed PEKILO (LAKSESVELA & SLAGSVOLD 1974)

% PEKILO in feed	-	10	10	10
Methionine, added, g/kg	-	-	2.0	-
Methionine-hydroxy/analogue, g/kg	-	-	-	1.2
Basic feed supplied with herring meal:				
Growth rate, relative fig.	100	97	91	96
FCR, " "	100	98	99	100
Basic feed				
Growth rate, relative fig.	100	84	91	89
FCR, relative fig.	100	112	103	105

SUMMARY

The Norwegian studies for evaluating PEKILO as a protein source in poultry feeding may be devided into two main sections:

1. Biological evaluation by laboratory methods.
2. PEKILO as a substitute for soybean meal in practical rations for chickens.

The experimental results show that PEKILO may replace soybean meal as a protein source provided that methionine is added to the ration. This may also be achieved by combining PEKILO with other protein sources rich in sulphur-containing amino acids, e.g. herring meal.

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PEKILO-PROTEIN IN POULTRY AND SWINE FEEDING IN POLAND

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In looking for new sources of protein, Pekilo-protein product has recently been developed in Finland.

The product contains up to 50% crude protein and can be successfully used as a protein supplement in formulating diets for farm animals.

To confirm the results obtained in other studies, the Institute of Animal Husbandry in Poland has carried out a series of trials on Pekilo-protein as a substitute for other protein supplements in poultry, swine and calf feeding.

In this short report the results of the experiments on broilers and growing-finishing swines are presented.

P O U L T R Y

The experiment was carried out on 960 Dominant White Cornish x White Rock broilers. The main object of the experiment was to compare the performance of broilers fed diets with differing amounts of soybean and/or Pekilo-protein.

The percentage composition of the diets used in four different treatments is shown in table 3 and 3a.

The birds were housed in broiler house on deep-litter throughout the experiment.

The results of the experiment are given in tables 4, 5, 6 and 7.

On the basis of this study it was concluded that:
1. It is possible to substitute at least 2/3 of the soybean meal with Pekilo-protein in starter and finisher rations in feeding broilers without negative effects on body gain. When soybean meal was completely replaced by Pekilo-protein the body weight gain up to 8 weeks of age was depressed.

2. Substitution of soybean meal by Pekilo-protein had positive effects on feed conversion. When Pekilo-protein was used with soybean meal or instead of soybean meal the feed conversion efficiency was improved by 2,2-4,8%.

3. Slaughter characteristics, chemical composition and pH of breast muscle were not affected by the level of Pekilo-protein in the diets.

4. The blood serum test (protein level and aspartate aminotransferase activity) indicated that it is likely that the process of biosynthesis of amino acids was slightly impaired when soybean meal was replaced by Pekilo-protein.

5. There was no effects of Pekilo-protein on the health of the broilers.

General conclusion:

In the experiment carried out here the Pekilo-protein has been proved to be a valuable source of protein supplement in broiler feeding.

Table 1. Percentage composition of the Pekilo
(Broilers exp., May-June, 1977)

Dry matter	-	92,18 %
Crude protein	-	45,48 %
Ether extract	-	1,20 %
Crude ash	-	5,71 %
Crude fibre	-	6,50 %
N-free extract	-	33,29 %

Table 2. Amino acid composition of the Pekilo and soybean meal protein (g/kg).

	Pekilo	Soybean meal
Serine	22,3	23,3
Glycine	25,5	20,1
Cystine	3,1	-
Threonine	23,4	19,3
Proline	22,8	23,1
Alanine	33,7	20,2
Phenylalanine	22,8	23,3
Tyrosine	15,9	12,1
Leucine	38,7	35,7
Isoleucine	26,5	22,0
Valine	28,6	22,4
Lysine	38,5	28,5
Arginine	37,1	30,3
Histidine	14,2	12,5
Glutamic acid	59,4	95,2
Aspartic acid	44,2	50,6
Methionine	6,3	3,9

Table 3. Percentage composition of the experimental diets.

	Starter				Finisher			
	1	2	3	4	1	2	3	4
Corn	49	49	49	49	60	60	60	60
Wheat	7	7	7	7	6	6	6	6
Fish meal	5	5	5	5	2	2	2	2
Skim milk powder	2	2	2	2	2	2	2	2
Feed yeast	2	2	2	2	-	-	-	-
Fat concentrate "Celat"	3	3	3	3	3	3	3	3
Soybean meal	29	19	9	-	23	15	8	-
Pekilo	-	10	20	29	-	8	15	23
Premix + minerals	3	3	3	3	4	4	4	4

Table 3a. Protein and energy level in experimental diets.

	Starter[x]				Finisher[xx]			
	1	2	3	4	1	2	3	4
In 1 kg:								
Crude prot. g	224	226	228	229	180	180	181	182
Lysine g	13,3	14,4	15,6	20,0	9,8	10,5	11,0	12,0
Met. + Cyst. g	7,7	7,3	6,8	6,4	6,4	6,0	5,8	5,4
ME kcal	2854	2854	2854	2854	2864	2864	2864	2864

x- in the diet 1, 2, 3 and 4 - 0, 10, 20 and 29 % Pekilo respectively

xx- in the diet 1, 2, 3 and 4 - 0, 8, 15 and 23 % Pekilo respectively

Table 4. Body gain and feed conversion of the Dominant White Cornish x White Rock broilers fed soybean meal or Pekilo diets.

	T R E A T M E N T (percent in starter/finisher)			
Soybean meal	29/23	19/15	9/8	0/0
Pekilo	0/0	10/ 8	20/15	29/23
No. of birds	240	240	240	240
	Period: 0-4 weeks			
Initial body weight, g	33,6	34,0	32,9	33,5
Final body weight, g	583	600	602	601
Feed/gain ratio	2,27	2,12	2,04	2,05
	Period: 0-8 weeks			
Final body weight, g	1495	1527	1538	1452
Feed/gain ratio	2,71	2,61	2,58	2,65
Losses, %	10,0	8,7	6,7	5,0

Table 5. Slaughter analysis of the DW.C x WR broilers fed soybean meal or Pekilo diets.

	T R E A T M E N T (percent in starter/finisher)			
Soybean meal	25/23	19/15	9/8	0/0
Pekilo	0/0	10/ 8	20/15	29/23
No. of birds	8	8	8	8
Body weight before slaughter, g	1520	1547	1546	1476
Carcass weight, g	1017	1032	1056	988
Dressing percentage, %	66,9	66,7	67,5	66,9
Giblets in percentage of body weight, %	4,4	4,1	4,2	4,4
Breast muscle, g	98	93	101	97
Gizzard, g	29	28	27	27
Body cavity fat, g	15	16	14	9
Liver, g	32	30	32	32

Table 6. Chemical composition and pH of the breast muscle of the DWC x WR broilers fed soybean meal or Pekilo diets.

	T R E A T M E N T (percent in starter/finisher)			
Soybean meal	29/23	19/15	9/8	0/0
Pekilo	0/0	10/ 8	20/15	29/23
No. of birds	8	8	8	8
Dry matter, %	26,35	25,83	25,63	25,62
Protein, %				
- total	23,74	23,54	23,62	23,70
- soluble[x]	4,41	4,50	4,63	4,66
Fat[x], %	1,12	1,08	0,65	0,53
Ash, %	1,19	1,19	1,14	1,14
pH	5,86	5,86	5,83	5,91

x- significant differences between groups ($P < 0,05$)

Table 7. Blood serum proteins and ASp AT activity in DWC x WR broilers fed soybean meal or Pekilo diets.

	T R E A T M E N T (percent in starter/finisher)			
Soybean meal	29/23	19/15	9/8	0/0
Pekilo	0/0	10/8	20/15	29/23
Total protein[x], %	3,22	3,34	3,79	3,68
Of the total proteins (%):				
- Albumins	51,55	52,11	51,00	50,21
- Alpha globulins	19,98	19,80	20,48	20,23
- Beta globulins	13,51	12,94	14,11	14,57
- Gamma globulins	14,96	15,14	14,41	15,03
Protein index (albumins/globulins ratio)	1,06	1,09	1,04	1,01
Asp AT[xx] activity[x] ,IU	75,8	75,1	74,0	70,8

x- significant differences between entirely Pekilo and soybean meal treatment ($P < 0,05$).

xx- Asp AT= aspartate aminotransferase

S W I N E

The experiments were carried out with the aim to show how the substitution or fish meal (experiment 1) or oilmeals (experiment 2) by Pekilo-protein in the protein concentrate may affect the performance of growing-finishing swine.

E x p e r i m e n t 1. A total of 64 pigs were involved in this trial. There were four treatments of 16 pigs in each. Pigs of the control group were fed a fish meal based diet and in the experimental groups the fish meal was substituted partly or entirely by Pekilo-protein. Pigs were on trial from 30 to 90 kg live weight and were fed a complete mixture composed of protein concentrate (table 1) and the basal grain mixture (table 2).

The protein concentrate and the basal mixture were combined in such a way to get a 15% crude protein concentration troughout the experiment.

The daily feed allowance was restricted to the following scale:

Period	Feed kg/pig/day
30-50	1,65
50-70	2,35
70-90	2,60

E x p e r i m e n t 2. The second experiment was similar to the first one with respect to the number of animals, the basal grain mixture and the feeding procedure. The only difference was in the composition of the protein concentrate. In this trial Pekilo-protein was used as a substitute for oilmeals (soybean and peanut meal) and yeast in the concentrate (table 8). The level of fish meal in the

concentrate remained constant for all treatments.

The results of the two experiments are given in tables 3, 4, 5, 6, 7, 9, 10 and 11.

On the basis of the experiments carried out at the Institute the following conclusions can be drawn:

1. There was no adverse effect of Pekilo-protein used as a substitute for fish meal or oilmeals on the growth rate of growing-finishing swine.

Only in the first trial, pigs which were fed a diet with all fish meal withdrawn and substituted by Pekilo-protein had slightly lower daily gains than those on the other treatments.

2. There was no negative effect of Pekilo-protein on feed conversion when this product was used for replacement of oilmeals in the protein concentrate. When fish meal was entirely withdrawn in the concentrate and substituted by Pekilo-protein, the feed conversion was significantly worse.

3. The results od slaughter analysis showed that Pekilo-protein in the diet seems to have positive effect on pig carcass meatness.

4. Chemical composition, pH and water holding capacity of the m. long. dorsi were not affected by replacing fish meal or oilmeals with Pekilo-protein in the diet for growing-finishing pigs.

There also were no differences in lard iodine numbers between treatments.

5. In the digestibility trial it was shown that fat and NFE digestion was poorer when Pekilo-protein was included in the diet. The digestibility of other nutrients was not affected by Pekilo-protein.

6. In the balance trial a tendency was observed for better N retention in the pigs on the Pekilo-protein diets.

General conclusion:

As in case with broiler feeding also in pig feeding the Pekilo-protein can be considered as a valuable source of protein supplement.

Table 1. Percentage composition of the protein concentrate used in swine feeding trial (Exp., 1).

	1	2	3	4
Pekilo	0	10,2	19,8	30
Fish meal	30	19,8	10,2	-
Soybean meal	15	15	15	15
Peanut meal	40	40	40	40
Yeast	5	5	5	5
Limestone	2	2	2	2
Phosphate	6	6	6	6
Premix (Micro-Tavit)	2	2	2	2
	100	100	100	100
In 1 kg:				
Dig. prot., g	399	394	374	354
Oat units	1,00	1,01	1,03	1,05

Table 2. Percentage composition of the basal mixture used in swine feeding trial (Exp., 1).

Barley	50 %
Corn	25 %
Dried Sugar beets	25 %
	100
In 1 kg:	
Dig. prot., g	66
Oat units	1,09

Table 3. Performance of growing pigs fed fish meal and/or Pekilo diets (Exp., 1).

	TREATMENT (percentage of Pekilo/fish meal in protein concentrate)			
	0/30	10,2/19,8	19,8/10,2	30/0
No. of pigs	16	16	16	16
Daily gain, g:				
30-50 kg	652[a]	610[b]	612[b]	534[a]
50-70 kg	610	641	621	604
70-90 kg	504	503	565	504
30-90 kg	589	584	599	547
Feed conversion: (kg feed/kg gain)				
Period:				
30-90 kg	3,85[b]	3,85[b]	3,69[b]	4,05[a]

a, b - averages denoted by different superscripts differ significantly ($P<0,05$).

Table.4. Slaughter analysis of the pigs fed fish meal and/or Pekilo diets (Exp. 1)[x].

	TREATMENT (percentage of Pekilo/fish meal in protein concentrate)			
	0/30	10,2/19,8	19,8/10,2	30/0
Carcass length, cm	79	79	80	79
Backfat thickness:				
- over shoulder, cm	4,0	3,9	3,9	3,8
- average of 5 measurements, cm	2,78	2,78	2,62	2,76
Loin eye area, cm^2	31,0	31,0	31,0	32,0
Meat in ham, %	65,01	66,41	63,92	66,89
Meat in primal cuts, kg	16,22[a]	17,10[b]	16,89[b]	17,18[b]

a, b - averages denoted by different superscripts differ significantly, ($P<0,05$)

x- pigs were slaughtered at 90 kg live weight

Table 5. Chemical composition, pH, water holding capacity of m, long. dorsi and iodine number of lard of pigs fed fish meal and/or Pekilo diets (Exp., 1)

	TREATMENT (percentage of Pekilo/fish meal in protein concentrate)			
	0/30	10,2/19,8	19,8/10,2	30/0
In m. long. dorsi, %:				
-dry matter	25,21	25,04	25,02	25,37
-protein	21,80	22,03	22,03	22,17
-ether extract	1,34	1,21	1,31	1,37
-ash	1,15	1,20	1,20	1,13
pH	5,56	5,58	5,54	5,57
Water holding capacity, cm^2	34,63	32,88	34,94	32,94
Lard iodine number	60,42	59,29	59,02	57,19

Table 6. Digestibility (%) of nutrients in fish meal and Pekilo diets fed to growing pigs (Exp., 1)

	TREATMENT (percentage of Pekilo/fish meal in protein concentrate)			
	0/30	10,2/19,8	19,8/10,2	30/0
Dry matter	80,74	80,37	78,34	80,20
Crude prot.	74,64	73,23	70,33	72,57
Fat	60,65[a]	50,88[b]	41,02[b]	41,58[b]
Crude fibre	50,70	50,31	47,02	46,19
N-free extracts	90,84[a]	90,34[b]	89,09[b]	90,05[b]

a, b - averages denoted by different superscripts differ significantly (fat - $P< 0,01$, NFE - $P< 0,05$)

Table 7. Nitrogen balance in growing pigs fed fish meal and/or Pekilo diets (Exp. , 1)

	TREATMENT (percentage of Pekilo/fish meal in protein concentrate)			
	0/30	10,2/19,8	19,8/10,2	30/0
Daily N intake, g	63,89	58,35	57,81	58,27
N-digested, g	47,70	42,76	40,78	42,33
Apparent N digestibility, %	74,66	73,28	70,54	72,64
N retained, g	28,75[b]	27,72[b]	22,06[a]	27,63[b]
N retained as a percentage of intake, %	45,00[b]	47,51[b]	38,16[a]	47,42[b]
N retained as a percentage of digested, %	60,27[b]	64,82[b]	54,10[a]	65,27[b]

a, b - averages denoted by different superscripts differ significantly, ($P<0,05$)

Table 8. Percentage composition of the protein concentrate used in swine feeding trial (Exp., 2).

	1	2	3	4
Pekilo	-	20,4	39,6	60,0
Fish meal	30,0	30,0	30,0	30,0
Soybean meal	15,0	9,9	5,1	-
Peanut meal	40,0	26,4	13,6	-
Yeast	5,0	3,3	1,7	-
Limestone	2,0	2,0	2,0	2,0
Feed phosphate	6,0	6,0	6,0	6,0
Premix (Micro-Tavit)	2,0	2,0	2,0	2,0
	100	100	100	100
In 1 kg:				
Dig.prot., g	413	415	417	419
Oat units	1,00	1,05	1,10	1,15

Table 9. Performance of growing pigs fed oilmeals and/or Pekilo diets (Exp., 2)

	TREATMENT (percentage of Pekilo/oilmeals and yeast in protein concentrate)			
	0/60	20,4/39,6	39,6/20,4	60/0
No. of pigs	16	16	16	16
Daily gain, g:				
30-50 kg	496	518	492	524
50-70 kg	628	577	585	606
70-90 kg	519	553	537	542
30-90 kg	548	549	538	557
Feed conversion: (kg feed/kg gain)				
Period:				
30-90 kg	4,03	3,99	4,07	3,94

Table 10. Slaughter analysis of the pigs fed oilmeals and/or Pekilo diets (Exp., 2)

	TREATMENT (percentage of Pekilo/oilmeals and yeast in protein concentrate			
	0/60	20,4/39,6	39,6/20,4	60/0
Carcass length, cm	78	78	78	79
Backfat thickness:				
- over shoulder, cm	3,7	3,9	3,7	3,9
- average of 5 measurements, cm	$2,6^{b}$	$2,5^{b}$	$2,4^{b}$	$2,8^{a}$
Loin eye area, cm^2	29^{a}	34^{b}	32^{b}	35^{b}
Meat in ham, %	66,50	66,00	67,50	66,56
Meat in primal cuts, kg	16,49	16,81	17,22	16,94

a, b - averages followed by different superscripts differ significantly ($P<0,05$ for backfat and $P<0,01$ for loin eye area)
x - pigs slaughtered at 90 kg live weight

Table 11. Chemical composition, pH, water holding capacity of m. long. dorsi and iodine number of lard of pigs fed oilmeals and/or Pekilo diets (Exp., 2)

	TREATMENT (percentage of Pekilo/oilmeals and yeast in protein concentrate)			
	0/60	20,4/39,6	39,6/20,4	60/0
In m. long dorsi, %:				
- dry matter	25,33	25,14	25,29	25,50
- protein	20,97	20,79	21,41	21,33
- ether extract	1,21	0,91	1,07	1,18
- ash	$1,13^{b}$	$1,11^{b}$	$1,12^{b}$	$1,09^{a}$
pH	5,55	5,53	5,54	5,53
Water holding capacity, cm^2	29,29	29,70	28,83	29,40
Lard iodine number	60,82	61,05	62,66	61,67

PEKILO-PROTEIN IN THE FEEDING OF GROWING FINISHING DUCKS

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Protein demand of the fast growing hybrid ducks is difficult to secure adequently without supplemental feeds containing plenty of proteins. Such proteins are for example the single cell proteins.

For this reason it was agreed that possibility to compensate 25 %, 50 % and 75 % of fish meal with Pekilo protein should be investigated and at the same time compare its productivity effects with the feed yeasts.

The experiment was performed with seven duck groups. Up to the age of seven days all groups received a feed mixture with the following composition: - corn 32, wheat 22.93, sunflower meal 8, soyabean meal 15, fish meal 8, dried skim milk 12, alfalfa meal 2 and chalk meal 0.07 %. The mixture contained 24.03 % of crude protein, 3054 kcal/kg of metabolizable energy, 1.04 % of calcium, 0.79 % of phosphorus and 1.52 % of lysine.

When ducks had reached the age of 8 days, experiment groups were formed. Minimum weight of the animals in the groups was 184.4 g and maximum 188.6 g. There were no statistical differencies between average weights of the test groups.

Feeding of the ducks was continued with the test mixtures. Composition of the mixtures and results of the test feeding up to the age of 20 days are shown on table 1.

At the age of 21 days, composition of the mixtures was changed at the same time as the requirements of ducks for nutritives decreased. With these feed mixtures the ducks were fed in both experimental and control groups up

to the age of 49 days (second growing stage). Composition of the feed mixtures and growth of the ducks as well as feed consumption during this period are shown in the table 2.

Conclusion

According to results obtained in this experiment, the following conclusion can be drawn:

Replacing fishmeal with Pekilo and hydrolyze yeasts does not decrease growth speed of the ducks. On the contrary it has favourable effect upon their meat productivity.

Table 1. Composition (%) of experimental diets, body weight gain and feed intake of broiler ducks at the first period (8-20 days)

	Groups						
	1	2	3	4	5	6	7
Corn meal	32,82	33,55	36,77	37,00	34,75	36,08	36,40
Wheat meal	20,00	20,00	20,00	20,00	20,00	20,00	20,00
Barley meal	10,00	9,00	5,00	5,00	10,00	8,00	5,00
Pea meal	5,00	5,00	5,00	5,00	3,00	3,00	5,00
Sunflower meal	9,00	7,00	6,00	2,00	7,00	6,00	3,00
Soyabean meal	11,00	13,00	14,00	17,00	13,00	14,00	17,00
Fish meal	8,00	6,00	4,00	2,00	6,00	4,00	2,00
Alfalfa meal	2,50	2,50	2,50	2,50	2,50	2,50	2,50
Bone meal	1,50	1,20	1,60	2,12	0,13	0,84	1,56
Pekilo	-	2,00	4,00	6,00	-	-	-
Yeast	-	-	-	-	2,00	4,00	6,00
Chalk meal	0,10	0,50	0,68	0,80	1,34	1,15	0,93
Salt	-	0,13	0,28	0,47	0,13	0,27	0,43
Methionine	0,077	0,122	0,160	0,222	0,12	0,13	0,132
Calculated analyses per 100 g:							
Crude protein, g	20,7	20,7	20,6	20,2	20,5	20,5	20,7
ME kcal	292,5	292,3	292,2	290,9	294,5	293,4	291,6
Calcium, mg	1203,4	1204,7	1200,9	1192.3	1204,2	1203,0	1199,7
Phosphorus, mg	813,3	799,9	788,5	799,9	804,5	801,8	801,3
Lysine, mg	1106,6	1131,2	1200,9	1159,7	1119,4	1129,8	1205,3
Body weight in the age of 21 days, g	993,4	1047,8	1078,0	1069,2	1079,8	1058,8	1090,6
Weight gain, g	806,5	861,4	889,4	880,7	892,1	870,7	903,3
Feed intake g/day	128,3	128,3	128,3	128,3	128,4	132,8	128,3

Table 2. Composition (%) of experimental diets, body weight gain and feed intake of broiler ducks at the second period (21-49 days)

	Groups						
	1	2	3	4	5	6	7
Corn meal	27,60	27,23	29,56	30,00	27,17	27,82	29,48
Wheat meal	25,00	25,00	25,00	25,00	25,00	25,00	25,00
Barley meal	15,00	15,00	13,00	13,00	15,00	14,00	13,00
Pea meal	4,00	4,00	3,00	3,00	4,00	4,00	3,00
Sunflower meal	3,00	3,00	-	-	3,00	2,00	2,00
Soyabean meal	13,00	13,00	16,00	15,07	13,00	14,00	14,00
Fish meal	5,00	3,70	2,50	1,20	3,70	2,50	1,30
Alfalfa meal	5,00	5,00	5,00	5,00	5,00	5,00	5,00
Bone meal	1,60	1,92	2,22	2,36	1,90	2,12	2,11
Pekilo	-	1,30	2,50	3,80	-	-	-
Yeast	-	-	-	-	1,30	2,50	3,70
Chalk meal	0,358	0,484	0,580	0,810	0,450	0,490	0,770
Salt	0,260	0,345	0,460	0,540	0,340	0,430	0,500
Methionine	0,147	0,128	0,162	0,188	0,110	0,120	0,132
Calculated analyses per 100 g:							
Crude protein, g	18,7	18,6	18,5	18,01	18,7	18,7	18,5
ME kcal	285,6	284,2	284,9	284,4	284,0	283,5	283,8
Calcium, mg	1201,2	1203,7	1203,3	1205,6	1202,6	1198,3	1201,2
Phosphorus, mg	799,7	799,3	800,3	806,6	801,2	799,9	800,2
Lysine, mg	1018,3	1007,8	1043,8	1002,5	1014,4	1029,0	1010,6
Average body weight, g	2699	2626	2744	2678	2731	2626	2573
Weight gain, g	1706	1578	1666	1609	1652	1567	1485
Feed intake g/day	228	228	228	227	229	228	224

OPTIMAL STANDARDS WHEN CHANGING FROM THE ANIMAL PROTEIN TO PEKILO-PROTEIN

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In the poultry breeding station of Aleksejevskaja, located in Rostov area, the first phase of experiment was carried out in 1977. For this experiment four groups of 1 day old chicks, each group containing 150 chicks, were picked out. These chicks were kept in 3-level cages and were moved to different levels at the age of 20 days. Each chick had 312 cm^2 of space and growth time was 56 days.

Test feeding, according to the standards, was started at the age of 6 days. The mixtures of the first phase (1 to 28 days) contained metabolizable energy 12.5 MJ/kg, 21 % of crude protein and the mixtures of the second phase (29 to 56 days) contained 12.9 MJ and 19 % respectively.

The feed mixture of the control group contained animal protein including fish- and meat and bone meals 10 % in the first and 14 % in the second phase. The purpose of this experiment was to find optimal standards to compensate animal protein feeds with Pekilo-protein. 25, 50 and 75 % of animal proteins were compensated with Pekilo-protein. Slaughtering of chicks and classification of carcasses were performed at the age of 56 days. Growth speed, health and feed consumption against weight gain unit were considered as most important criteria.

Most important results of broiler growth and evaluation of their meat quality are presented in the table 1.

The results of the experiment show that by feeding up to 75 % of Pekilo-protein of quantity of animal proteins does not have any harmful effects on growth or development of the chicks and does not increase feed consumption per kilo weight gain. Results of biometrical determination did

not show any significant differences between average body weights of the groups. Classification of the carcasses into separate groups showed that the experimental group, which got 50 % of Pekilo from supplemental protein had 11 % more carcasses in the class I than the control group, 14 % more than Pekilo-25 group and 20.4 % more than Pekilo-75 group. This gave us basis to select the most appropriate alternative to compensate 50 % of animal protein with Pekilo and take it under control (I group) in experiment 2 in order to define optimal compensating standards. In the test groups the animal feeds were compensated with 40 % (II group) and 60 % (III group) from the crude protein. The most important results, which are shown in the table 2, prove very small differencies in growth and feed conversion. Biometrical values of the live weight did not show any significant differiences between the second and third group, but the difference is obvious between the first and other groups.

This confirmed our conclusion that optimal standards in compensating the animal protein with Pekilo-protein is 50 % in feeding of broilers.

Table 1. The most important results of the experiment 1.

	Groups			
	1 Control	2 25 % Pekilo	3 50 % Pekilo	4 75 % Pekilo
Number of chickens	150	150	150	150
Average body weight, g in the age of 56 days	1297±11,4	1282±17,1	1316±10,1	1266±16,2
Total weight gain, g	1248,8	1238,6	1273,7	1221,1
Daily weight gain, g	22,7	22,5	23,2	22,2
Mortality, %	6,7	8,0	7,4	4,0
Feed intake kg/kg gain	2,61	2,67	2,60	2,62
Carcass quality:				
I class, %	83,4	81,3	95,3	74,9
II " "	16,2	17,5	4,2	25,1
III " "	0,4	1,22	0,5	-

Table 2. The most important results of the experiment 2.

	Groups		
	1 50 % Pekilo (control)	2 40 % Pekilo	3 60 % Pekilo
Number of chickens	150	150	150
Average body weight, g in the age of 56 days	1309,6±16,4	1264±17,5	1257±16,4
Total weight gain, g	1277,6	1216,0	1215,0
Daily weight gain, g	22,8	21,7	21,7
Mortality, %	1,4	2,0	1,4
Feed intake kg/kg gain	2,44	2,63	2,61

PEKILO-PROTEIN IN ANIMAL FEEDING. I. NUTRITIVE VALUE IN BROILER FEEDING

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Trial 1. Composition and analysis of feed mixtures

	Treatment			
Components, %	A	B	C	D
Maize, ground	60.0	56.9	53.6	53.5
Soybean meal (44%)	26.7	27.4	28.1	28.1
Fish meal (62%)	8.0	4.0	-	-
Pekilo-protein	-	4.9	9.8	9.8
Swine lard	1.8	2.8	3.9	3.9
Dicalcium phosphate	1.4	1.8	2.4	2.4
Limestone	0.8	0.9	0.9	0.9
Salt	0.3	0.3	0.3	0.3
DL-methionine	-	-	-	0.1
Premix	1.0	1.0	1.0	1.0
Analysis, %:				
Moisture	9.72	9.41	9.59	9.86
Crude protein	21.71	21.53	21.47	21.58
Crude fat	5.75	6.34	7.81	7.76
Crude fiber	3.02	3.20	3.46	3.35
N-free extract	54.55	54.05	52.15	52.06
Ash	5.25	5.38	5.52	5.45

In control mixture (treatment A) on iso-protein-energetic base 50 % (treatment B) or 100 % (treatment C) fish meal was substituted for Pekilo, and the mixture with no fish meal (C) suplemented with 0,1 % methionine (treatment D) was also investigated. The feeds were given in meal form, ad libitum, and water was supplied from water fountains. Each treatment was investigated simultaneously with 3 groups per 200 chickens.

Statistical analysis of results for feed conversion, weight gain and efficiency of feed utilization.

Treatment	n	$\bar{X}$ x)	$S\bar{x}$	s	C	F - value Exp.	F - value Tab. 0.05	F - value Tab. 0.01	LSD 0.05	LSD 0.01
Average daily feed consumption per chicken, g										
A	3	43.0^{aA}	0.62	1.07	2.49					
B	3	45.6^{aA}	1.08	1.87	4.10	$77.4^{xx)}$	3.34	5.56	2.71	3.51
C	3	32.9^{bB}	0.71	1.00	3.04					
D	3	44.5^{aA}	0.95	1.80	4.04					
Average daily weight gain of chicken, g										
A	3	21.9^{aA}	0.40	0.70	3.20					
B	3	21.2^{aA}	0.35	0.60	2.83	$97.6^{xx)}$	3.34	5.56	1.22	1.57
C	3	15.5^{bB}	0.13	0.23	1.48					
D	3	20.8^{aA}	0.55	0.96	4.61					
Average feed conversion kg per unit of weight gain										
A	3	1.96^{aA}	0.006	0.010	0.51					
B	3	2.11^{bAB}	0.018	0.032	1.52	$7.57^{xx)}$	3.34	5.56	0.126	0.163
C	3	2.12^{bAB}	0.040	0.070	3.30					
D	3	2.15^{bBC}	0.067	0.117	5.44					

x) The values marked with different letters are significantly different at the level of 99 % ($P<0.01$).

xx) Significant difference at the level of 99 % ($P< 0.01$)

Quality of Pekilo-protein was investigated by biochemical "in vitro" method on amino analyser Beckman Spinco, 120 B in feeding trial with chicks compared to proteins from fish meal in the period from 0-5 weeks of age. One-day old chicks of fattening hybrid "ROS-I" were used in the conditions of floor breeding with thick straw litter.

On the base of results obtained in these investigations the following conclusions can be drawn:

- The investigated sample of Pekilo contained 51.3 crude protein, total lysine 6.04 % and methionine with cystine 2.57 % calculated in total protein, its biological value in relation to the whole egg is 68.56.

- Substitution of 50 % fish meal for Pekilo had not significant influence on feed consumption and weight gain, but feed consumption in treatment B per unit of weight gain was significantly higher ($P < 0.05$) than in treatment A.

- Total substitution of fish meal for Pekilo (Treatment C) decreased very significantly feed consumption and weight gain of chicks ($P < 0.01$) and increased feed consumption per unit of weight gain ($P < 0.05$) compared to treatment A.

- Adding 0.1 % methionine in feed with no fish meal (Treatment D) improved feed consumption and body weight to the level of treatment A, but feed consumption per unit of weight gain was still significantly higher ($P < 0.05$) compared to control.

- Negative influence of fish meal substitution for Pekilo in treatments B, C and D is the consequence of deficiency of methionine with cystine (Treatment B), methionine with cystine and lysine (Treatment C) and lysine (Treatment D) compared to treatment A.

- The protein quality of Pekilo is very good, but in the case of isoprotein substitution with fish meal in feeding of broilers, sulfinic amino acids can appear as the first limiting amino acids, and depending on the level of the substitution, lysine probably as the second limiting amino acid.

Trial 2. Composition and analysis of feed mixtures.

Components, %	Treatment E	F	G
Maize, ground	56.80	57.00	56.80
Soybean meal	26.00	25.90	25.80
Fodder yeast	9.00	4.50	-
Pekilo protein	-	4.90	9.80
Sunflower oil	3.70	3.20	3.00
Dicalcium phosphate	2.20	2.30	2.40
Limestone	1.00	0.90	0.90
Salt	0.30	0.30	0.30
Premix	1.00	1.00	1.00
Analysis, %:			
Moisture	10.36	10.62	10.44
Crude protein	21.59	21.55	21.68
Crude fat	7.46	7.33	6.98
Crude fiber	3.21	3.44	3.52
N-free extract	52.16	51.63	51.87
Ash	5.22	5.43	5.51

In control mixture (treatment E) on iso-protein-energetic base was substituted 50 % (treatment F) or 100 % (treatment G) proteins from feed yeast for Pekilo-protein. Each treatment was simultaneously investigated on 48 chicks divided into 6 groups per 8 chicks. The feeds were given in meal form, ad libitum, water was supplied from water fountains.

Statistical analysis of results for feed conversion, weight gain and efficiency of feed utilization.

Treatment	n	$\bar{x}$	$S\bar{x}$	s	C	F - value Exp.	F - value Tab.
I Average daily feed consumption per chick, g							0.05
E	6	47.8	0.300	0.736	1.54		
F	6	48.8	0.632	1.549	3.17	1.37^{NS}	3.68
G	6	48.7	0.529	1.297	2.66		
II Average daily weight gain of chicken, g							
E	6	22.4	0.234	0.573	2.56		
F	6	23.2	0.332	0.814	3.51	1.93^{NS}	3.68
G	6	22.5	0.404	0.989	4.40		
III Average feed conversion kg per unit of weight gain.							
E	6	2.12	0.029	0.072	3.40		
F	6	2.09	0.032	0.078	3.74	2.28^{NS}	3.68
G	6	2.17	0.020	0.050	2.30		

NS - Not significant

Quality of Pekilo-protein was investigated in feeding trial with chicks compared to protein of feed yeast in the period from 0-5 weeks of age. One-day old chicks of both sexes, fattening hybrid ROS-I were used in the conditions of battery breeding.

On the base of results obtained the following conclusions can be drawn:

- Substitution of 50 % (Treatment F) or 100 % (Treatment G) of feed yeast proteins for Pekilo-protein did not significantly influence the average daily feed consumption, weight gains and efficiency of feed utilization compared to the control with no Pekilo-protein (Treatment E).

- Pekilo contains slight amounts of lysine as feed yeast and this fact must be considered at formulation of diets, since the deficiency of this amino acid can be produced.

II. NUTRITIVE VALUE IN FEEDING OF WEANED PIGLETS

Composition and analysis of feed mixtures.

Components, %	Trial I			Trial II		
	Treatment					
	A	B	C	D	E	F
Maize, ground	67.65	67.10	66.35	71.35	68.85	66.40
Soybean meal	12.90	12.90	12.90	12.90	12.90	12.90
Milk powdered	5.00	5.00	5.00	5.00	5.00	5.00
Fish meal (70%)	-	-	-	7.30	3.65	-
Fodder yeast	9.15	4.55	-	-	-	-
Pekilo-protein	-	4.90	9.85	-	4.90	9.85
Soybean oil	2.05	2.25	2.50	1.25	1.90	2.50
Dicalcium phosphate	0.90	1.10	1.30	0.50	0.90	1.25
Limestone	1.05	0.90	0.80	0.40	0.60	0.80
Salt	0.30	0.30	0.30	0.30	0.30	0.30
Premix	1.00	1.00	1.00	1.00	1.00	1.00
Analysis, %:						
Moisture	9.93	9.84	9.41	9.98	9.65	9.43
Crude protein	18.67	18.37	18.43	18.74	18.24	18.23
Crude fat	5.15	5.28	5.57	4.70	5.07	5.55
Crude fiber	2.69	2.94	3.20	2.80	3.07	3.20
N-free extract	59.37	59.37	59.31	59.91	60.20	59.89
Ash	4.19	4.20	4.08	3.87	3.77	3.70

Statistical analysis of results for feed consumption, weight gain and feed utilization (Trial I - Piglets)

Treatment	n	x	$S\bar{x}$	s	C	F - value Exp.	F - value Tab. 0.05	F - value Tab. 0.01	LSD 0.05	LSD 0.01
Average daily feed consumption per piglet, g										
	4	959[a]	19.0	38.0	3.96					
	4	936[a]	2.7	5.5	0.58	3.40[x)]	3.34	-	46	59
	4	959[a]	14.1	28.2	2.94					
Average daily weight gain of piglets, g										
A	4	503	7.3	14.7	2.91	NS				
B	4	490	6.0	12.0	2.44	1.44	3.34	-	-	-
C	4	489	2.8	5.7	1.16					
Feed conversion kg per unit of weight gain										
A	4	1.91	0.05	0.10	5.34	NS				
B	4	1.91	0.03	0.05	2.72	0.77	3.34	-	-	-
C	4	1.96	0.02	0.03	1.76					

NS - Not significant

x) - Significant difference at the level of 95 % ($P < 0.05$)

Statistical analysis of results for feed conversion, weight gain and feed utilization (Trial II - Piglets)

Treatment	n	$\bar{x}$ x)	$S\bar{x}$	s	C	F - value Exp.	F - value Tab. 0.05	F - value Tab. 0.01	LSD 0.05	LSD 0.01
Average daily feed consumption per piglet, g										
D	4	1.061	11.2	22.5	2.12					
E	4	1.073	18.1	36.3	2.38	3.03^{Ns}	3.34	-	-	-
F	4	1.061	24.0	48.1	4.53					
Average daily weight gain of piglets, g										
D	4	551^{aA}	9.39	18.8	3.41					
E	4	533^{aA}	6.54	13.1	2.45	$27.25^{xx)}$	3.34	5.56	22	29
F	4	484^{bB}	3.39	6.78	1.40					
Average feed conversion kg per unit of weight gain										
D	4	1.93^{aA}	0.04	0.09	4.72					
E	4	2.02^{aAB}	0.05	0.10	5.14	$6.94^{xx)}$	3.34	5.56	0.174	0.225
F	4	2.20^{bB}	0.06	0.12	5.44					

NS - Not significant ($P > 0.05$)

x) - Values marked with different small letters are significantly different at the level of 95 % ($P < 0.05$) and with capital letters at the level of 99 % ($P < 0.01$).

xx)- Significant difference at the level of 99 % ($P < 0.01$)

Quality of Pekilo-protein was investigated by biochemical "in vitro" method on amino analyser Beckman - Spinco, 120 B and in feeding trial with weaned piglets of average initial weight about 8 kg compared to feed yeast (Trial I) and fish meal (Trial II).

In trial I 50 (B) and 100 % (C) of feed yeast and in trial II 50 (E) and 100 % (F) of fish meal in the control mixture was substituted iso-protein-energetically for Pekilo. Each treatment, within the trial, was investigated simultaneously on 4 groups with 7 piglets. The feeds were fed in meal form

from metal feeders and water was supplied from water fountains. Piglets were kept in wire cages in a warmed room. The trial I lasted 35, and trial II 30 days.

On the base of results obtained in these investigations the following conclusions can be drawn:

- The investigated sample of Pekilo contained 51.3 % crude protein, total lysine 6.04 % and sulfnic amino acids 2.57 % calculated in total protein. Its biological value in relation to the whole egg is 68.56.

- Substitution of 50 % (Treatment B) or 100 % (Treatment C) of feed yeast on iso-protein base with Pekilo did not significantly influence feed consumption, weight gain and feed conversion compared to the control mixture (Treatment A) on the base of yeast.

- Iso-protein substitution of 50 % of fish meal (treatment E) with Pekilo did not significantly influence feed consumption, weight gain of piglets and feed conversion compared to control mash (treatment D).

- Complete substitution of fish meal with Pekilo (Treatment F) did not influence feed consumption, but very significantly decreased ($P < 0.01$) weight gain and increased feed consumption per kg of weight gain compared to control mash (Treatment D). The difference in rate of weight gain between treatments E and F was also very significant ($P < 0.01$) and the difference in feed conversion per 1 kg of weight gain between the above mentioned treatments was significant at the level of 95 % probability ($P < 0.05$).

- The negative influence of complete substitution of fish meal (Treatment F) with Pekilo was the consequence of deficiency of such a feed in sulfuric amino acids.

- Proteins in Pekilo are very good quality but at formulation of the mixtures, the attention must be paid on supplying methionine. Sulfuric amino acids in this case can be the first limiting amino acids in the diet.

PEKILO-PROTEIN IN ANIMAL FEEDING. III NUTRITIVE VALUE IN FEEDING OF GROWING AND FATTENING PIGS

The following protein feeds were used in the trial: imported fish meal and soybean meal, feed yeast produced by IPK "Crvenka" and Pekilo-protein imported from Finland.

The basic chemical and amino acid composition of the above protein feeds was determined in our laboratory. The basic chemical composition was determined by standard methods according to YUS, and amino acid composition on amino analyzer Beckman-Spinco, 120 B. Protein hydrolysis was performed according to Dustin et al. (1953) and determination of individual amino acids according to Moor et al. (1958) and Speckman et al. (1958). Enzymatic hydrolysis for determination of biological activity of amino acids and biological value of protein was performed according to Akeson and Stahmann (1964). Basic chemical and amino acid composition of protein feeds was given in Tables 1 and 2.

Pekilo protein was investigated as a substitute for fish meal and feed yeast in feeding of growing and fattening pigs.

Trial I

In the trial there were 36 piglets of Swedish Landrace type with initial body weight of about 22 kg. Experimental piglets were divided into two treatments. Each treatment consisted of three groups and each group consisted of 3 male and 3 female piglets. The trial was performed on P.D. "Doža Djerdja" in Bačka Topola in the period from 28th March to 18th July 1977. Body weight of piglets was registered at the beginning of the trial, at the end on the I fattening period and at the end of the trial. Experimental piglets were given diets of wet feed from troughs. The consumption of investigated mixtures is shown in Table 3. From the table it can be seen that mixture I in the 1'st fattening period contained 4.0 % and in the 2nd fattening period 2.0 % fish meal. The mixture II contained 5.4 % Pekilo

in the 1st fattening period and 2.7 % Pekilo in the 2nd fattening period. Substitution of fish meal for Pekilo was performed on the base of protein equivalent. Consequently, the mixtures with fish meal and Pekilo contained approximately the same percentages of protein (15.29 and 15.56 % in the first fattening period and 12.90 and 13.05 % in the second fattening period) - Table 3.

Trial II

36 piglets of Swedish Landrace type were included in the trial, their initial body weight was about 22 kg. Experimental piglets were divided into two treatments. Each treatment consisted of 3 groups, and each group included 3 male and 3 female piglets. The trial was performed on P.D. "Doža Djerdja" in Bačka Topola in the period from 28th March to 18th July 1977. Body weight was registered at the beginning of the trial, at the end of the first fattening period and at the end of the trial. Experimental piglets were given diets of wet feed from troughs. The composition of the investigated mixtures is shown in Table 5. It can be seen from the table that the mixture I contained 5.0 % feed yeast in the first fattening period and 2.5 % feed yeast in the second fattening period. The mixture II contained 5.4 % Pekilo in the first fattening period and 2.7 % Pekilo in the second fattening period. The substitution of feed yeast for Pekilo was performed on the base of protein equivalent. Consequently, the trial mixtures with feed yeast and Pekilo contained approximately the same percentages of protein (15.29 and 15.43 % in the first fattening period and 12.90 and 12.97 % in the second fattening period) - Table 5.

Composition of investigated mashes (%)
(Trial I) - Fattening swines

Components	Mashes			
	I fatt.period		II fatt.period	
	I	II	I	II
Maize, ground	72.3	72.0	80.0	80.0
Wheat bran	10.4	9.0	7.5	6.6
Soybean meal	10.6	10.6	7.5	7.5
Fish meal	4.0	-	2.0	-
Pekilo	-	5.4	-	2.7
Dicalcium phosphate	0.5	0.8	0.8	0.8
Limestone	0.9	0.9	0.7	0.9
Salt	0.3	0.3	0.5	0.5
Premix	1.0	1.0	1.0	1.0
Total	100.0	100.0	100.0	100.0
Crude protein, %	15.56	15.29	13.05	12.90

Composition of investigated mashes (%)
(Trial II) - Fattening swines

Components	Mashes			
	I fatt.period		II fatt.period	
	I	II	I	II
Maize, ground	72.0	72.0	80.0	80.0
Wheat bran	9.4	9.0	6.8	6.6
Soybean meal	10.6	10.6	7.5	7.5
Feed yeast	5.0	-	2.5	-
Pekilo	-	5.4	-	2.7
Dicalcium phosphate	0.8	0.8	0.8	0.8
Limestone	0.9	0.9	0.9	0.9
Salt	0.3	0.3	0.5	0.5
Premix	1.0	1.0	1.0	1.0
Total	100.0	100.0	100.0	100.0
Crude protein, %	15.43	15.29	12.97	12.90

Statistical analysis of results for feed consumption, weight gain and feed utilization (Trial I) - Fattening swines

Treatment	n	$\bar{x}$	$S\bar{x}$	s	C	"t - test" Exp.	Tab. 0.05	0.01
Average daily feed consumption, kg - I fattening period								
A	3	2.03	0.010	0.017	0.85	$4.24^{x)}$	2.78	4.60
B	3	1.97	0.010	0.017	0.88			
- II fattening period								
A	3	3.08	0.075	0.129	4.19	1.99^{NS}	2.78	4.60
B	3	2.91	0.041	0.071	2.43			
- Average for the whole trial								
A	3	2.54	0.029	0.050	1.97	1.07^{NS}	2.78	4.60
B	3	2.44	0.021	0.036	1.47			
Average daily weight gain, g - I fattening period								
A	3	783	10.54	18.25	2.33	$4.28^{x)}$	2.78	4.60
B	3	719	10.58	18.33	2.55			
- II fattening period								
A	3	766	46.23	80.07	10.45	1.72^{NS}	2.78	4.60
B	3	685	8.39	14.53	2.12			
- Average for the whole trial								
A	3	775	26.56	46.01	5.94	2.71^{NS}	2.78	4.60
B	3	702	4.28	7.42	1.06			
Feed conversion kg per unit of weight gain, - I fattening period								
A	3	2.59	0.022	0.039	1.49	$3.83^{x)}$	2.78	4.60
B	3	2.74	0.032	0.056	2.03			
- II fattening period								
A	3	4.02	0.142	0.245	6.10	1.62^{NS}	2.78	4.60
B	3	4.25	0.007	0.012	0.29			
- Average for the whole trial								
A	3	3.28	0.075	0.131	3.99	2.50^{NS}	2.78	4.60
B	3	3.48	0.027	0.047	1.35			

NS - The difference is not significant ($P > 0.05$).

x) - The difference is significant at the level of 95 % ($P < 0.05$)

Statistical analysis of results for feed consumption; weight gain and feed utilization (Trial II) - Fattening swines

Treatment	n	$\bar{x}$	$S\bar{x}$	s	C	"t - test" Exp.	Tab. 0.05	0.01
Average daily feed consumption, kg - I fattening period								
A	3	1.99	0.017	0.030	1.51	1.00^{NS}	2.78	4.60
B	3	1.97	0.010	0.017	0.88			
- II fattening period								
A	3	2.93	0.050	0.087	2.95	0.12^{NS}	2.78	4.60
B	3	2.91	0.041	0.071	2.43			
- Average for the whole trial								
A	3	2.46	0.021	0.036	1.46	0.71^{NS}	2.78	4.60
B	3	2.44	0.021	0.036	1.47			
Average daily weight gain, g - I fattening period								
A	3	724	12.77	22.11	3.05	0.30^{NS}	2.78	4.60
B	3	719	10.58	18.33	2.55			
- II fattening period								
A	3	727	18.88	32.70	4.50	2.03^{NS}	2.78	4.60
B	3	685	8.39	14.53	2.12			
- Average for the whole trial								
A	3	726	6.56	11.36	1.56	$3.06^{x)}$	2.78	4.60
B	3	702	4.28	7.42	1.06			
Feed conversion kg per unit of weight gain, - I fattening period								
A	3	2.75	0.030	0.052	1.89	0.23^{NS}	2.78	4.60
B	3	2.74	0.032	0.056	2.03			
- II fattening period								
A	3	4.03	0.064	0.111	2.76	$3.40^{x)}$	2.78	4.60
B	3	4.25	0.007	0.012	0.29			
- Average for the whole trial								
A	3	3.39	0.006	0.010	0.29	$3.25^{x)}$	2.78	4.60
B	3	3.48	0.027	0.047	1.35			

NS - The difference is not significant ($P > 0.05$).

x) - The difference is significant at the level od 95 % ($P < 0.05$).

Chemical composition and nutritive value of Pekilo-protein in feeding of growing and fattening swines were investigated. On the base of results obtained the following conclusions can be drawn:

1) Pekilo is microbial mass which is produced by micro fungus Paecilomyces Varioti. It is a highly concentrated protein feed containing 51.35 crude protein.

2) Pekilo-protein has the similar amino acid composition as feed yeast. It is rich in lysine and threonine, and relatively low in methionine and cystine.

3) Pekilo gave lower results in feeding of swines than fish meal. The swines fed Pekilo gained slower by 9.42 % and utilize feed less efficiently by 5.76 than the swines fed fish meal. Consequently, the partial substitution of fish meal for Pekilo is recommended.

4) Pekilo gave the similar results as feed yeast in feeding of pigs. Consequently, Pekilo can substitute feed yeast in feeding of growing and fattening swines.

5) Pekilo-protein is lower in lysine and methionine content than fish meal. If Pekilo-protein is enriched in these two amino acids, it can also successfully substitute for fish meal in diets for pigs.

ABSCHLUSSPROTOKOLL

Überprüfung des Produktionsnutzeffekts der kompleten Futtermischungen für die Vormast und Mast der Broiler bei Anwendung der "Pekilo"-Futterproteine

Zentrales Kontroll- und Prüfinstitut für Landwirtschaft, Prag

Exemplar Nr: 1

Die "Pekilo"-Futterproteine wurden in der Form von kleinen leichten Granullen,hell grauer Farbe geliefert. Nach dem mikroskopischen Befund wurde kleines kurzes Myzel ohne Beimischungen festgestellt. Der Gehalt von Grundmineralnährstoffen in der Trockensubstanz von 92,6 % belief sich auf 49,5 % bei stickstoffhaltigen Stoffen, auf 44,3 % bei reinen Proteinen, auf 1.876 kJ metabolisierbarer Energie , auf 5,5 % bei der Asche, auf 5 % beim Faserstoff.

Die Futterhefen werden gesondert auf der Basis der Technologie des Sulphitäthanols für die Bedürfnisse der Überprüfung im Zentralen Kontroll- imd Prüfinstitut für Landwirtschaft hergestellt. Ihre Qualitätsparameter entsprechen den perspektivischen Forderungen dieser Technologie. Der Nährstoffgehalt in der Trockensubstanz von 89,5 % war 51, 2 % stickstoffhaltige Stoffe, 45,4 % reine Proteine, 1.732 kJ metabolisierbare Energie, 5,9 % Asche, 0,3 % Faserstoff.

Methode der Durchführung der biologischen Teste

Die biologischen Teste verliefen in zwei parallelen Versuchsetappen. Jede Etappe bestand aus fünf wiederholten Versuchen, die vom März bis Mai 1978 verliefen.

In der zweiten Etappe wurden Futtermischungen für die Mast der Broiler angewandt, in denen die Gehalte der Tierproteine nach den staatlichen Rezepturen des Jahres 1977-1978 reduziert wurden.

Der Gehalt der geprüften Pekiloproteine ebenso wie der verglichenen Futterhefen in den Futtermischungen war 6 %. Für den Bedarf der Veterinärverfolgung wurde noch eine Gruppe mit einem Anteil von 10 % der Pekiloproteine eingereiht.

Die Teste wurde in den bilogischen Teststationen des Zentralen Kontroll- und Prüfinstituts für Landwirtschaft gesichert.

Die Hühner waren in den Versuchsobjekten auf Tiefstreu untergebracht. Die Aufstallung war bei allen Gruppen gleich.

Für die Versuche wurden eintägige sexierte Hühner der ROSS-Fleischhybride gebraucht und sie wurden in beiden Etappen stichprobenartig in zwei Gruppen so eingeteilt, dass die gebildeten Gruppen ausgeglichene Ganzen darstellten. Die Hühner wurden durch Flügelzeichen individuell bezeichnet.

Für die Fütterung wurden komplete Mischungen für die Vormast der Broiler BR 1 und für die Mast dieser Hühner BR 2 verwendet.

Die Zusammenstellung der Versuchsmischungen, der verwendeten Ergänzungen der Biofaktoren und die Nährmineralzugaben sind in den Tabellen 1, 2 und 3 angeführt.

Die Futtermischungen wurden in der Produktionsanlage der Versuchsnährmittel des Zentralen Kontroll- und Prüfinstituts für Landwirtschaft aus homogenisierten und vorher analytisch überprüften Rohstoffen hergestellt. Die analytische Kontrolle der Rohstoffe und der hergestellten Versuchsmischungen wurde in den Labors des Zentralen Kontroll- und Prüfinstituts durchgeführt.

Die analytische Charakteristik des geprüften Materials ist in der Tabelle 4 und die Aminosäurengehalte in der Tabelle 5 angeführt. Die analytische Charakteristik der Versuchsmischungen steht in der Tabelle 6.

Schema und Organisation des Versuches

Gruppe 1: komplette Mischungen BR 1 und BR 2 nach den staatlichen Rezepturen des Jahres 1977-1978 mit 6 % Futterhefen
Bezeichnung der Mischungen: BR 1 - 1/1977-1978
BR 2 - 1/1977-1978

Gruppe 2: komplette Mischungen BR 1 und BR 2 nach den staatlichen Rezepturen des Jahres 1977-1978 mit 6 % Pekiloproteinen
Bezeichnung der Mischungen: BR 1 - 2/1977-1978
BR 2 - 2/1977-1978

Mit den Mischungen für die Vormast der Broiler /BR 1/ wurden die Hühner bis zum 28. Tag ihres Alters, mit den Mischungen für die Mast der Broiler /BR 2/vom 28. bis 49. Tag ihres Alters gefüttert.

Die Mischungen wurden im Trockenstand ohne Zugabe anderer Nährmittel durch die ad libitum Methode verfüttert. Frisches Tränkwasser war ständig in Tränkebecken und Grit in einem Sonderfütterer zur Verfügung.

Die Zunahmen der lebendigen Masse wurden durch individuelles Wägen am 28. Tag des Alters der Hühner und nach der Beendigung des Versuches am 49. Tag festgestellt.

Verlauf und Ergebnisse der biologischen Teste

Die verfolgten Hauptfaktoren waren die Zunahmen der lebendigen Masse, der Futtermittelverbrauch, der Gesundheitszustand der Versuchshühner und deren Reaktion auf die gereichten Futtermittel.

Die Ergebnisse der Teste in den beiden Etappen wurden zusammenfassend verarbeitet und durch Analyse der Zerstreuung ausgewertet. Der Produktionsnutzeffekt wurde durch ein Koeffizient des Produktionswertes de. Futterstoffes nach Brüggemann bestimmt.

Die zusammenfassenden Ergebnisse des Versuches der ersten Etappe sind in der Tabelle 7 a,b,c angeführt und die Überprüfung der Unterschiede der Zunahmen der lebendigen Masse durch Analyse der Zerstreuung steht in der Tabelle 9.

Die zusammenfassenden Ergebnisse des Versuches der zweiten Etappe sind in der Tabelle 8 a,b,c aufgeführt und die Überprüfung der Unterschiede der Zunahme der lebendigen Masse durch Analyse der Zerstreuung steht in der Tabelle 10.

Ergebnisse der biologischen Teste der zweiten Etappe /Rezeptur 1977-1978/

In der Kategorie bis zum 28. Tag des Alters der Broiler, d.h. während der Verfütterung der BR 1-Mischungen, wies die Gruppe 2 /BR 1-Mischung mit Pekiloprotein/ gegenüber der Gruppe 1 /BR 1-Mischung mit Futterhefen/ eine statisch bedeutende Erhöhung der Zunahmen der lebendigen Masse / Index 105,9/ bei einem verminderten Futtermittelverbrauch für 1 kg der Zunahme der lebendigen Masse /Index 95,6/ auf. Der Koeffizient des Produktionswertes des Futtermittels nach Brüggemann wies einen Wert von 105,2 auf.

In der Kategorie vom 28. bis 49. Tag des Alters der Broiler, d.h. während der Verfütterung der BR 2 Mischungen, wies die Gruppe 2 /BR 2-Mischung mit Pekiloprotein/ gegenüber der Gruppe 1 /BR 2-Mischung mit Futterhefen/ eine statistisch bedeutende Erhöhung der Zunahmen der lebendigen Masse /Index 103,2/ bei einem verminderten Futtermittelverbrauch für 1 kg der Zunahme der lebendigen Masse /Index 99,6 / auf. Der Koeffizient des Produktionswertes des Futtermittels nach Brüggemann wies einen Wert von 101,8 auf.

Während der ganzen Periode der Versuchsmast, d.h. bis zum 49. Tag des Alters der Broiler, wies die Gruppe 2 /BR 1 und BR 2-Mischung mit Pekiloprotein/ gegenüber der Gruppe 1 /BR 1 und BR 2-Mischung mit Futterhefen/ eine statistisch bedeutende Erhöhung der Zunahmen der lebendigen Masse /Index 104,4/ bei einem verminderten Futtermittelverbrauch für 1 kg der Zunahme der lebendigen Masse /Index 98,1/ auf.

Im Verlauf der biologischen Teste wurden keine Mängel von gesundheitlichem Charakter festgestellt.

Der Gesundheitszustand der Versuchshühner wurde durch Adspektion verfolgt und ausserdem wurden während des Versuches aus jeder Gruppe Hühner für Laboruntersuchungen im Zentralen staatlichen Veterinärinstitut in Prag regelmässig abgenommen.

Die Entwicklung der verfolgten Organe wies in den einzelnen Alterskategorien in Beziehung zur lebendigen Masse keine wesentlichen Unterschied zwischen den Gruppen auf.

Im Verlauf des Versuches gingen je drei Tiere aus jeder Gruppe, einschliesslich der Kontrollhühner, ein. Der häufigste Befund, der bei den eingegangenen Hühnern festgestellt wurde, war die Leberdegeneration und der akute Darmkatarrh.

Aus den im Zentralen staatlichen Veterinärinstitut in Prag durchgeführten Untersuchungen kann die Schlussfolgerung gezogen werden, dass das Pekilo-Proteinpräparat keine toxische Auswirkung auf den Gesundheitszustand der Hühner hat.

Bei der sensorischen Beurteilung des Fleisches und der Brühen aus dem Fleisch der Hühner aus den einzelnen Gruppen hat eine Kommission der Staatlichen Qualitätsinspektion von Lebensmittelprodukten festgestellt, dass bei keiner der Proben solche Mängel bemerkbar waren, die ihre geläufige Anwendung ausschliessen würden.

Schluss:

In den durchgeführten biologischen Testen wurde der Produktionsnutzeffekt der Futterproteine aus dem Pekilo-Prozess überprüft, wobei sie mit Futterhefen tschechoslowakischer Provenienz verglichen wurden, die in den kompletten Mischungen für die Mast von Broilern eingegliefert sind.

Parallel damit verlief Überprüfung der Unschädlichkeit für die Gesundheit, die veterinärärtzliche Untersuchung der Versuchshühner im Labor und die sensorische Beurteilung der Schlachthühner aus den biologischen Testen.

Aus den Ergebnissen folgt:

1. Die Einreihung von 6 % der Pekilo-Futterproteine in die kompletten Futtermischungen mit verminderter Vertretung von Tierproteinen nach den staatlichen Rezepturen des Jahres 1977-1978 hat eine statistisch bedeutende Erhöhung der Zunahmen der lebendigen Masse /Index 104,3/ bei einem verminderten Futtermittelverbrauch für 1 kg der Zunahme der lebendigen Masse /Index 98,1/ aufgewiesen. Durch Einschätzung der einzelnen Alterskategorien mit Hilfe des Koeffizienten des Produktionsnutzeffekts nach Brüggemann ist der Produktionsnutzeffekt besonders in der Katagorie der Vormast wesentlich besser.

2. Auf der Grundlage der Laboruntersuchungen, die vom Zentralen staatlichen Veterinärinstitut durchgeführt wurden, hat die Zugabe der Pekilo-Futterproteine keine toxische Aiswirkung auf den Gesundheitszustand der Hühner.

3. Auf der Grundlage der sensorischen Beurteilung des Fleisches der Versuchstiere, die von der Staatlichen Qualitätsinspektion von Lebensmittelprodukten durchgeführt wurde, wurden keine Mängel befunden, die die Qualität des Fleisches beeinflussen könnten.

Tabelle 1. Zusammensetzung der Versuchsmischungen in %.

1. Etappe- staatliche Rezepturen des Jahres 1977-1978

	BR 1-1	BR 1-2	BR 2-1	BR 2-2
Weizen	38,7	38,7	11,8	11,8
Mais	30,0	30,0	57,0	57,0
extr. Sojaschrott	17,0	17,0	21,0	21,0
Getreidekeime	2,0	2,0	-	-
Fischmehl	3,0	3,0	1,0	1,0
Blutschrott	-	-	-	-
Fleischknochenmehl	1,0	1,0	1,0	1,0
Futterhefen	6,0	-	6,0	-
Pekiloprotein	-	6,0	-	6,0
Heumehl	-	-	-	-
MKS 2	1,0	1,0	1,0	1,0
Futtersalz	0,3	0,3	0,2	0,2
DB BR 1	1,0	1,0	-	-
DB BR 1	-	-	1,0	1,0
Insgesemt	100,0	100,0	100,0	100,0

Tabelle 2. Zusammensetzung der Biofaktorenergänzungen.

	DB BR 1-77-78	DB BR 2-77-78
Nitrovin, mg	1 500	1 500
A-Vitamin, m.j.	1 000 000	800 000
D_3-Vitamin, m.j.	100 000	80 000
D_2-Vitamin, mg	300	300
B_{12}-Vitamin, mg	2	2
K_3-Vitamin, mg	200	200
Niazin, mg	1 200	-
Methionin, mg	100 000	100 000
Amprol Plus, mg	50 000	50 000
Kurasan, mg	12 500	12 500
Futtermehl, ad	1 kg	1 kg

Tabelle 3. Zusammensetzung des Futtermineralzusatzes für Geflügel (MKP 2)

Futterkalkstein, mikrogemahlen	%	67,0
"MD II" Mineralzusatz	%	1,0
Polyphos	%	17,0
entleimtes Knochenmehl	%	15,0
insgesamt	%	100,0

Zusammensetzung des MD II Mineralzusatzes

Kupfer (II)-sulfat	mg	30 000
Eisen (II)-sulfat	mg	80 000
Zinkoxyd	mg	220 000
Mangan (II)-karbonat	mg	550 000
Kaliumjodid	mg	5 000
Kobalt (II)-sulfat	mg	100
Futtermehl	mg	30 000
Gibs	ad	1 kg

Tabelle 4. Analytische Charakteristik des geprüften Materials
(Zentrales Laboratorium des OŽV ÚKZÚZ Praha)

	Futterhefen	Pekilo
Wasser, %	10,5	7,4
Trockensubstanz, %	89,5	92,6
stickstoffhaltige Stoffe (N x 6,25), %	51,2	49,5
Fett nach der Hydrolyse, %	5,9	3,9
Asche, %	5,9	5,5
Faserstoff, %	0,3	5,0
in HCl unlösbarer Rest, %	0,11	0,44
stickstoffreie Auszugsstoffe, %	26,2	28,7
stickstoffhaltige verdauliche Stoffe, %	38,8	36,1
Koeffizient der Verdaulichkeit der stickstoffhaltigen Stoffe	76	73
Proteine, %	45,4	44,3
Verdauliche Proteine, %	33,0	30,9
Amide, %	5,8	5,2
Kalzium, g/kg	1,3	1,4
Phosphor, g/kg	18,2	13,2
nichtverseifbarer Fettanteil, %	1,8	6,0
Wasserablaugeadizität, mg KOH/100 g	1629	620
Gesamtadizität der Wasserablauge, mg KOH/100 g	2460	1470
pH	5,3	5,1
Schwefel, g/kg	2,4	0,14
Semiquantitative Spektralanalyse der Asche:		
mehr als 10 %	K,P,Ca,Mg	P,K,Ca,Mg
1-10 %	Na	-
0,1-1 %	-	-
0,01-0,1 %	Zn,Al,Si,(Fe)	Mn,Na,Fe
weniger als 0,01 %	Ni,Cd,Pb,Mn,Ag,Cu, B,(Ba,V,Sr,Fi)	Zn,Si,Al,Ag,B (Cu,Pb)
ME, KJ/kg	17320	18760

Tabelle 5. Aminosäurengehalte der geprüften Futterstoffe
(in der ursprünglichen Probe)

	PEKILOprotein	Futterhefen
Asparaginsäure	4.02	4.30
Threonin	2.07	2.51
Serin	2.19	2.48
Glutamsäure	5.97	6.92
Prolin	1.97	1.80
Glyzin	2.10	2.15
Alpha-Alanin	2.92	2.83
Zystin nach der Oxydationshydrolyse	nicht festgestellt	nicht festgestellt
Valin	2.27	2.85
Methionin nach der Sauerhydrolyse	0.76	1.07
Isoleuzin	1.87	2.70
Leuzin	3.35	3.72
Thyrosin	1.61	1.82
Phenylalanin	1.84	2.22
Lysin	3.11	3.80
Histidin	1.08	1.06
Arginin	3.02	2.62
Tryptophan	nicht festgestellt	nicht festgestellt

Tabelle 6. Analytische Charakteristik der Versuchsmischungen

	2. Etappe staatliche Rezepturen 1977-1978			
	BR 1-1	BR 1-2	BR 2-1	BR 2-2
Wasser, %	12.9	12.9	11.6	12.0
Trockensubstanz, %	87.1	87.1	88.4	88.0
stickstoffhaltige Stoffe (N x 6.25), %	19.9	18.7	20.7	20.4
Fett, %	2.8	3.0	3.2	3.2
Asche, %	4.4	4.4	4.2	4.5
Faserstoff, %	4.4	4.5	3.4	3.1
stickstoffreie Auszugsstoffe, %	55.6	56.5	56.9	56.8
in HCl unlösbarer Rest der Asche, %	0.14	0.12	0.08	0.10
Kalziumkarbonat, %	0.8	0.9	0.8	0.9
Natriumchlorid, %	0.47	0.66	0.38	0.47
ME, kJ/kg	11490	11524	11700	11735

Tabelle 7. Zusammenfassende Ergebnisse der Versuche

K a t e g o r i e	0 - 28 Tag	
Gruppe	1	2
Zahl der Tiere	487	491
ø lebendige Masse am Anfang, g	-	-
ø lebendige Masse am Ende, g	614	650
ø Gesamtzunahme der lebendigen Masse, g	614	650
Dauer des Versuches	28	28
I n d e x	100	105.9
Durchschnittlicher Futtermittelverbrauch für 1 kg der Zunahme der lebendigen Masse		
BR 1	2.29	2.19
I n s g e s a m t, kg	2.29	2.19
I n d e x	100	95.6
Koeffizient des Produktionswertes des Futtermittels	100	105.2
Durchschnittlicher Nährstoffverbrauch für 1 kg der Zunahme der lebendigen Masse in kg		
Trockensubstanz	1.99	1.91
NL	0.456	0.410
ME, kJ	26312	25238

Tabelle 8 a. Zusammenfassende Ergebnisse der Versuche

K a t e g o r i e	28 - 49 Tag	
Gruppe	1	2
Zahl der Tiere	487	491
⌀ lebendige Masse am Anfang, g	614	650
⌀ lebendige Masse am Ende, g	1540	1606
⌀ Gesamtzunahme der lebendigen Masse, g	926	956
Dauer des Versuches	21	21
I n d e x	100	103,2
Durschnittlicher Futtermittelverbrauch für 1 kg der Zunahme der lebendigen Masse		
BR 2	2.82	2.81
I n s g e s a m t, kg	2.82	2.81
I n d e x	100	99.6
Koeffizient des Produktions-wertes des Futtermittels	100	101.8
Durchschnittlicher Nährstoffverbrauch für 1 kg der Zunahme der lebendigen Masse in kg		
Trockensubstanz	2.48	2.48
NL	0.581	0.579
ME, kJ	32994	32975

Tabelle 8 b. Zusammenfassende Ergebnisse der Versuche

K a t e g o r i e	0 - 49 Tag	
Gruppe	1	2
Zahl der Tiere	487	491
⌀ lebendige Masse am Anfang, g.	-	-
⌀ lebendige Masse am Ende, g	1540	1606
⌀ Gesamtzunahme der lebendigen Masse, g	1540	1606
Dauer des Versuches	49	49
I n d e x	100	104.3
Durchschnittlicher Futtermittelverbrauch für 1 kg der Zunahme der lebendigen Masse		
BR 1	0.913	0.887
BR 2	1.70	1.67
I n s g e s a m t, kg	2.61	2.56
I n d e x	100	98.1
Durchschnittlicher Nährstoffverbrauch für 1 kg der Zunahme der lebendigen Masse in kg		
Trockensubstanz	2.30	2.25
NL	0.531	0.510
ME, kJ	30380	29819

Tabelle 9. Überprüfung der Unterschiede in den Zunahmen der lebendigen Masse durch Analyse der Zerstreuung

II. Etappe

Kategorie vom 0 bis 28 Tag des Alters

Gruppe	1	2
1	-	$+36^{x}$
2		-

Die Bedeutsamkeitsgrenze bei 95 % Wahrscheinlichkeit = 12 g
Statistisch bedeutende Unterschiede in den Zunahmen der lebendigen Masse sind durch ein x bezeichnet

Kategorie vom 28 bis 49 Tag des Alters

Gruppe	1	2
1	-	$+30^{x}$
2		-

Die Bedeutsamkeitsgrenze bei 95 % Wahrscheinlichkeit = 12 g
Statistisch bedeutende Unterschiede in den Zunahmen der lebendigen Masse sind durch ein x bezeichnet

Kategorie vom 0 bis 49 Tag des Alters

Gruppe	1	2
1	-	$+60^{x}$
2		-

Die Bedeutsamkeitsgrenze bei 95 % Wahrscheinlichkeit = 29 g
Statistisch bedeutende Unterschiede in den Zunahmen der lebendigen Masse sind durch ein x bezeichnet.

PEKILO - A PROTEIN SOURCE OF THE BROILER FEED MIXTURE

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Conclusion

Two experiments have been performed with 199 hybride broiler chickens under the cage conditions. Effect of Pekilo-protein in replacing feed yeast, fish meal and soyabean meal in broiler feeds was researched.
Pekilo is a Finnish product, which is produced by cultivating continuously microfungus (Fungi Imp.) on sulphite spent liquor.

According to the results the following conclusions have been drawn:

1 In the broiler feeds, which do not contain any animal proteins, but which in regard to amino acids have been balanced, Pekilos portion of 6 % does not have negative effect upon the weight development of the chickens or their feed consumption.

2 While replacing completely feed yeast and partly soyabean meal with Pekilo, any disturbances in the weight development of the chickens were not noted. Fish meal portion in the mixtures was 4 %.

3 No 3.4-bentspyrenine content was present in Pekilo or in the meat of the chickens fed with mixtures containing Pekilo.

Table 1. Experimental arrangement. Compositions of feed mixtures, %.

Group	Experiment 1			Experiment 2			
No.	Yeast	Soya	Pekilo	Yeast	Fish meal	Soya	Pekilo
1	5.0	32.0	-	5.0	-	29.2	-
2	-	32.0	6.0	5.0	4.0	23.4	-
3	-	26.0	12.0	-	4.0	23.4	5.0
4	-	-	-	-	4.0	18.3	10.0

Table 2. Compositions of feed mixtures.

Components, %	Experiment 1			Experiment 2			
Corn	59.12	58.09	58.06	62.60	64.80	64.80	64.70
Soyabean meal	32.00	32.00	26.00	29.20	23.40	23.40	18.30
Feed yeast	5.00	-	-	5.00	5.00	-	-
Fish meal	-	-	-	-	4.00	4.00	4.00
Pekilo	-	6.00	12.00	1.20	-	5.00	10.00
$CaCO_3$	1.00	1.00	2.00	1.00	0.80	0.80	1.00
Dicalciumphosphate	1.80	1.80	1.80	0.50	1.00	1.00	1.00
Mixture of vitamins	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Mixture of minerals	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Methionine	0.06	0.07	0.09	-	-	-	-
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Crude protein, %	21.72	21.75	21.76	20.51	20.51	20.50	20.50
Lysine, %	1.27	1.27	1.27	1.19	1.22	1.18	1.17
Methionine + cystine	0.79	0.79	0.79	0.70	0.74	0.73	0.73
Calcium, %	0.94	0.94	0.95	0.81	0.84	0.83	0.80
Phosphorus, %	0.75	0.74	0.77	0.62	0.73	0.70	0.73

Table 3. Weight gain of chickens.

Group	Experiment 1				Experiment 2			
No	35 pv		56 pv		35 pv		56 pv	
	g	Rel.	g	Rel.	g	Rel.	g	Rel.
1	817	100.0	1684	100.0	716	100.0	1561	100.0
2	806	98.7	1683	100.0	820	114.4	1660	106.3
3	925	113.2	1628	96.7	785	109.9	1629	104.3
4	-	-	-	-	812	113.4	1711	109.6

Table 4. Feed consumption / weight gain, g/kg.

Group	Experiment 1				Experiment 2			
No.	g	Rel.	g	Rel.	g	Rel.	g	Rel.
1	4051	100.0	2.437	100.0	3879	100.0	2.539	100.0
2	4001	98.7	2.425	99.5	4079	105.2	2.472	97.4
3	4174	103.0	2.521	103.4	3736	96.3	2.343	92.3
4	-	-	-	-	4119	106.2	2.445	96.3

Table 5. Carcass analyses.

Values, %	Groups 1	2	3
Moisture	69.43	70.06	70.80
Crude protein	17.58	17.34	18.22
Crude fat	12.00	12.57	9.75
Ash	0.94	0.92	0.94
Slaughtering result	67	65	65

Table 6. Content of polysyclic aromatic hydrocarbons, g/kg

	Pekilo	Meat Samples Control group	Test group
Anthracene	4.08	0.20	0.20
Phenantrene	-	-	-
Pyrene	12.75	0.46	0.46
Fluoranthene	17.55	1.00	1.30
1.2-benzanthracene	7.77	-	-
Chrysene	-	-	-
3.4-benzanthracene	unnoticed	unnoticed	unnoticed
1.2-benzanthracene	20.91	0.87	1.55

PEKILO-SYMPOSIUM IN TAMPERE 12.-15.9.1978
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PEKILO IN THE FEEDING OF POULTRY
THE RESULTS OF THE EXPERIMENTS CARRIED OUT IN FINLAND

INTRODUCTION

The single cell protein (SCP), mainly dryed yeast, has been used up to day only in small quantities in the feeding of poultry. The use has been mainly based upon supplementing the vitamins, and not so much upon protein and energy. The world wide increased demand for the protein as well as need to utilize different substances and industry wastes, which as such are unfit for nourishment to both people and animals, have within past ten years increased the cultivation of the single cell proteins such as yeasts, microfungi and bacteria with different substrates containing carbon. Because the use of the single cell protein might be on different scale than previously, it is utmost important to know how it affects productivity and health of the animals.

During last few years a lot of research work has been done on availability of the single cell protein. In these experiments, where fishmeal and soyabean meal have been compensated with hydrocarbon yeasts or with bacterial protein, it has been possible to raise the amount up to 10 - 15 % without difficulties in the diets of laying hens and broilers. (D'MELLO 1973 a and b, SENO etc 1973, WALDROUP and PAYNE 1974, TIEWS etc 1974, BECK etc 1974, VOGT etc 1975, WALDROUP and HAZEN 1975, YOSHIDA 1975, RUSSO and MARIAN 1976 D'MELLO and ACAMOVIC 1976).

In rations of laying hens SCP has been even a sole protein supplement present, in other words covering more than 50 % of protein. Harmless top level for broilers has usually been 30 to 40 % of the dietary protein. If the protein portion has been 50 % or more, growth and feed efficiency of c chickens has usually lessened. In the finisher of broilers hydrocarbon yeast has gone without difficulties, as a sole protein supplement (SHANNON and McNAB 1972).

Amount of supplemented methionine naturally has an effect on achieved results, because it is the first limiting amino acid in the single cell protein. Arginine has been mentioned as the second limiting amino acid for growing poultry. Generally speaking the single cell protein has not have negative effect upon fertility and hatchability. According to SENO etc (1973) the low B_{12}-content of hydrocarbon yeast caused poor hatchability, Also dustiness of the single cell protein could have had an effect upon results decreasing feed consumption. It has been noted that pelleting of feed improves experimental results with the single cell protein.

Pekilo-product, which is microfungus (Paecilomyces varioti) cultivated in in the sulphite spent liquor has been devoloped in Finland and was manufactured for a first time as pilot plant product in the beginning of 1970. Then the feeding trials were carried out with laying hens and broilers. Later on one feeding experiment have been carried out with laying hens along with Torula-yeast, which is also produced in Finland.

The preliminary experiment in 1970-71

The results have been published in English in the paper presented by POUTIAINEN. Here I' ll only give some short comments on them. Two feeding experiments were carried out with laying hens. In these experiments fish-meal was compensated with proportions of 0, 50 and 100 % of Pekilo. In the second experiment also imported Torula-yeast was included additionally. The small amounts of hens, fewness of replications and short duration were deficiencies in these experiments (But maybe under those conditions nothing more sufficient could be afforded). However according to experimental results it can be seen, that under Finnish conditions at least half of the fishmeal protein can be compensated with Pekilo or also with Torula-yeast. The fact that no methionine has been added to the feeds, is one defect or error of the experiments, as it is the limiting amino acid in SPC. In addition the protein level of the rations surprisingly high from 19 to 20 %, which could have had an effect upon results. It would have been reasonable trying to achieve isocaloric mixtures with fat supplements. In the experiments with broilers, proportion of 33, 66 and 100 % of the protein in fish-meal and soyabean meal were substituted by Pekilo protein. Each group had 90 chicks, out of which about half were kept in the separate cages. The diets contained protein 23,5 % average and methionine supplement was not used in this experiment either.

The growth results are shown in figure 4 (POUTIAINEN) and also in the table 1 of this report. Average weight of the male chicks at the age of 8 weeks decreased when Pekilo-quantities were increased. Growth of chicks did not

decrease considerably until up at 100 % level. The differences are hardly statistically significant at least not between levels of 0 and 33 %.

If the methionine supplement would have been used and perhaps in addition to this the relatively low ME-concentration of Pekilo would be compensated with fat supplement in these first feeding experiments with poultry the results would have been even more positive on Pekilo and especially on its protein. Feed industry which uses SCP-products is quite capable to carry out these measures.

Feeding test with laying hens 1975-76

Purpose of this test was to compare both single cell proteins PEKILO and SILVA (Torula) manufactured in Finland against soyabean meal at three different protein level of feed.

Experimental material and methods

Test animals were WL-hens (SK 12) whose age at the beginning of the experiment was about 28 weeks. Hens were kept in the cages (stair model), each containing 3 hens. The experiment was 3 x 3 factorical: three protein supplements (soyabean meal, Pekilo, Silva) and tree protein levels (17, 15 and 13 %). In all there were 9 diets, and each diet consisted 6 replications each having 15 hens.

The compositions and calculated contents of the diets are shown in the table 2. Equivalent diets are almost isocaloric, because ME-concentration values of soyabean meal and single cell proteins are of same class. With methionine supplement we tried to reach about same sulphur amino acid level in all diets. Representative sample was taken of protein raw materials, barley, oat and feed mixtures of every lot. The usual feed analysis (table 3) were carried out on the samples. Egg production was measured daily and feed consumption in the periods of 28 days. Duration of the experiment was 9 periods or about 8,5 months. Quality determinations on eggs were done (specific weight albumen height, Haugh Unit) and after the experiment blood samples were taken out of the animals for the following determinations: Hb, haematocrite, protein, urea and uric acid of serum.

Results

According to the analysis protein content of the diets was about 0,5 % below the calculated values (table 3). Reason for this has been lower than expected protein content (table 3) of the protein feeds and grains. Death rate was highest in the soya group (7,0 %) and lowest in the Silva-group (2,6 %.

Between protein levels there weren't any differences in the death rates. Average weights of the hens were quite of same size in the different groups and on protein levels both at the beginning and end of the experiment. Thus change of weight had either any great differences (table 4). Percentage of weight gain from starting weight varied from 7,5 to 9,5 %.

In the laying results differences between different protein diet groups were slight and not statistically significant (table 5). Differences between protein levels were also surprisingly small. At the lowest protein level laying was as average 1 %-unit lower than others. Weight of egg was at the level of 13 % 0,8 g lighter than others ($P < 0,05$), but between the protein supplement groups there were no statistically significant differences. The animals were fed 22, 18 and 16 g of protein daily and metabolizable energy respectively was 324, 320 and 317 kcal daily at the different protein levels. In the feed efficiency differences were also small and not statistically significant.

Hb-values on the animals of single cell protein groups are somewhat lower than of soya group, but difference is not statistically significant (table 7). Statistically significant ($P < 0,01$) differences can be found in hemoglobine values between protein level of 17 % and other levels. There appears no significant differences in the haematicrite.

Total protein content of serum was significantly ($P < 0,01$) lower in the single cell protein groups than in soya groups. Instead there appeared no significant differences between the protein levels. Compared against soya SCP increased slightly the uric acid content of serum and decreased urea content. As regards the latter mentioned, difference was significant ($P < 0,05$). Protein level had an effect especially upon the uric acid content and at the level of 17 % it was significantly higher than others. Also the urea content was highest at the 17 % level, but not significantly. Specific weight and quality of the egg did not differ considerably between the protein diet groups and the protein levels (table 8).

Discussion

The fact that in the experiment just as good laying result was reached with the SCP-products than with the soya meal is not surprising in any way. Equivalent results have been reached also with the hydrocarbon yeasts and bacterial proteins (WALDROUP and HAZWN 1975, VOGT etc 1975, RUSSO and MARIANI 1976). As previously was noted methionine supplement is necessary. Also an satisfactory result of the lowest protein level, actually 12,5 % is not so surprising, because even with as low as from 11 to 13 g/d of protein quantities the satisfactory laying results have been reached (FERNANDEZ etc

1973, KOLSTAD AND LIEN 1974, MULLER and BALLOUN 1974) and in this experiment daily dose of the protein was with aforementioned group 16 g due to the great feed consumption caused by it's relatively low ME-concentration.

It seems that quite low at least 15 % protein level obviously can used in the Finnish conditions even when supplemented protein formed solely of soya or SCP. Norwegians have achieved at the protein level of 13 and 12 % just as good results as with higher levels, having or not having the fish-meal in the diet (SOLBERG 1971, KOLSTAD and LIEN 1974). Just as in this experiment, decreasing of protein content down to 10 - 12 % has clearly lessened weight of the egg (BALLOUN and SPEERS 1969, JENNIGS etc 1972, MULLER and BALLOUN 1974). It has also been noted that in other experiments the SCP has not had any harmful effects upon albumen quality of the egg (YOSHIDA etc 1974, VOGT etc 1975, WALDROUP and HAZEN 1975).
In this experiment the SCP products did not reduce the consumption of the diet. Relatively low energy content of the diets, obviously was not limiting factor in the production, because daily requirement for this weight class hens is 300 to 320 kcal/ME/d. This can also be seen from increased weights of the hens during the experiment.
As far as the mortality is concerned the differences between protein supplement groups hardly are depending upon diets because mostly the reason for death was cannibalism. About the blood values it is difficult to say anything certain, as the samples were taken only of part pf the animals and one sample at the end of the experiment. Most understandable result was increasing of end product of nitrogen metabolism, mainly uric acid, while protein level increased. Whether the SCP-products reduced the protein- and urea content of the serum is uncertain even though differences are statistically significant. Slight rise of the uric acid seems understandable, even though it has not always appeared (SHANNON and McNAB 1972, D'MELLO 1973 a).

Summary

This paper describes the poultry feeding experiments carried out in Finland with single cell protein. In these experiments the dried micro-fungi Paecilomyces varioti known as PEKILO cultivated in the sulphite spent liquors of the pulping industry has been used as the protein supplement. Up to now three experiments have been carried out in Finland with the laying hens and one experiment with broilers. According to these experiments and many others carried out in several countries with SCP, PEKILO can be used as the sole crude protein supplement in the diet of the laying hens, as long as sufficient methionine supplement is used. In any case the soyabean meal can be fully compensated with Pekilo and other SCP products. In the broiler diet Pekilo can be consumed at least up to 10-15 % or 30-40 % of protein as according to foreign reseaches also other SCP-products.

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Table 1. The growth and feed consumption of broilers (POUTIAINEN 1973)

Group	1 Pekilo 0 %		2 Pekilo 1/3 of fish and soya proteins		3 Pekilo 2/3 of fish and soya proteins		4 Pekilo 100 % of fish and soya proteins	
	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀
Number of chickens in the begining	48	42	43	47	49	41	47	43
Dead	6	3	3	-	-	-	2	1
Weight in the age of 1 day	43	42	43	42	43	42	43	42
" " " " " 56 days	1866	1495	1837	1456	1795	1457	1713	1357
Gain in weight g/day	32,6	25,9	32,0	25,3	31,3	25,3	29,8	23,5
Slaughter weight g	1313	1014	1285	989	1264	995	1177	929
" " %	70,3	67,8	70,0	67,9	69,9	68,3	68,7	68,5
Feed consumption g DM/animal/day	61,8	50,0	62,0	51,3	62,0	52,0	60,4	49,9
" " kg DM/kg gain in weight	1,85	2,05	2,06	1,89	1,78	2,20	2,00	2,18
Feed consumption kg DM/kg slaughter weight	2,63	3,11	2,94	2,78	2,54	3,21	2,79	3,19

Table 2. The compositions of diets and calculated concentrations of some nutritive factors in the experiment with laying hens 1975-76

Diet	1	2	3	4	5	6	7	8	9
Soyabean meal	20,00	-	-	14,00	-	-	8,00	-	-
Pekilo	-	18,00	-	-	12,50	-	-	7,50	-
Silva	-	-	18,00	-	-	12,50	-	-	7,50
Barley	46,00	47,00	47,00	50,00	51,00	51,00	54,50	55,00	55,00
Oat	20,50	21,50	21,50	22,50	23,00	23,00	24,00	24,00	24,00
Alfa-alfa meal	4,00	4,00	4,00	3,97	3,97	3,97	3,94	3,94	3,94
Soya oil	0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,50
Dicalcium phosphate	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00
Calcium carbonate	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00
Sodium chloride	0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,50
Sodium sulphate	0,12	0,12	0,12	0,12	0,12	0,12	0,12	0,12	0,12
Premix of micro minerals 1)	0,24	0,24	0,24	0,24	0,24	0,24	0,24	0,24	0,24
Premix of vitamins 2)	0,12	0,12	0,12	0,12	0,12	0,12	0,12	0,12	0,12
DL-methionine	0,02	0,02	0,02	0,05	0,05	0,05	0,08	0,08	0,08
	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00
Calculated concentrations:									
Crude protein	17,0	17,0	17,0	15,0	15,0	15,0	13,0	13,0	13,0
ME	2455	2455	2455	2465	2465	2465	2475	2475	2475
Methionine	0,27	0,29	0,29	0,28	0,29	0,29	0,29	0,29	0,29
Cystine	0,36	0,30	0,30	0,34	0,30	0,30	0,32	0,29	0,29
Lysine	0,86	0,85	0,85	0,72	0,70	0,70	0,59	0,57	0,57

1) Supplemented amounts of minerals: Fe 20, Zn 25, Cu 3, Mn 30, Co 0,5, 0,5 and Se 0,1 ppm.
2) Supplemented amounts of vitamins: A 15000 iu/kg, D_3 1800 iu/kg E 20, K 1,0, B_2 3,5, B_6 1,0, B_{12} 0,015, niacin 18, choline 500 and folic acid 0,3 mg/kg.

Table 3. The analytical data of the diets and raw materials.

	Dry matter	Crude protein	Crude fat	Crude fibre	N-free extractives	Ash
			%			
Diet 1	88,5	16,6	2,9	6,6	53,2	9,2
" 2	89,8	16,2	2,8	7,1	54,0	9,7
" 3	89,9	16,4	2,8	6,5	54,2	10,0
" 4	89,1	14,4	2,8	6,2	56,3	9,4
" 5	89,6	14,3	2,9	6,9	56,0	9,5
" 6	89,4	14,5	2,8	6,4	56,1	9,6
" 7	89,0	12,7	2,5	6,4	57,1	9,9
" 8	89,4	12,4	2,9	6,4	58,1	9,6
" 9	89,2	12,4	2,9	6,1	58,4	9,4
Soyabean meal	88,6	43,5	1,8	6,5	31,4	5,4
Pekilo	92,0	44,8	1,3	8,3	32,1	5,5
Silva	92,3	45,3	1,4	3,8	34,7	7,1
Barley	89,2	10,5	1,9	3,2	71,6	2,0
Oat	89,4	11,5	4,7	9,3	60,6	3,3

Table 4. The mortality and weight of hens

	Mortality %				Weight kg in the beginning of experiment				Weight in the end of experiment				Gain in weight %			
Protein %	17	15	13	$\bar{X}$	17	15	13	$\bar{X}$	17	15	13	$\bar{X}$	17	15	13	$\bar{X}$
A soya	6,7	7,7	6,7	7,0	1,95	1,95	1,91	1,94	2,12	2,12	2,10	2,11	8,7	8,9	9,6	9,1
B Pekilo	7,7	2,2	5,5	5,2	1,97	1,94	1,92	1,94	2,15	2,09	2,10	2,11	9,3	8,0	9,2	8,8
B Silva	1,1	3,3	3,3	2,6	1,94	1,96	1,92	1,94	2,11	2,11	2,07	2,10	8,7	8,0	7,5	8,0
$\bar{X}$	5,1	4,4	5,1		1,95	1,95	1,92		2,13	2,11	2,09		8,9	8,3	8,8	

Table 5. The most important data of production

Protein %	Laying % 17	15	13	$\bar{X}$	Eggweight g 17	15	13	$\bar{X}$	Corrected laying % (57 g) 17	15	13	$\bar{X}$
A Soya	68,0	66,2	66,6	66,9	59,8	59,4	58,5	59,2	70,9	68,5	67,4	68,9
B Pekilo	67,6	68,3	67,7	67,8	58,8	59,0	58,0	58,6	69,4	70,5	68,7	69,5
C Silva	69,2	69,3	66,4	68,3	59,0	59,0	58,8	58,9	71,3	71,4	68,2	70,3
$\bar{X}$	68,3	67,9	66,9		59,2	59,2	58,4		70,5	70,1	68,1	
t_{A-B}	0,81	1,04	0,51	0,78	1,65	0,71	0,92	1,90				0,58
t_{A-C}	0,62	1,61	0,10	1,21	1,35	0,79	0,46	1,00				1,32
t_{B-C}	0,92	0,54	0,58	0,44	0,30	0,06	1,44	0,96				0,77
	t_{17-15}	t_{17-13}	t_{15-13}		t_{17-15}	t_{17-13}	t_{15-13}		t_{17-15}	t_{17-13}	t_{15-13}	
	0,29	1,17	0,86		0,05	2,33*	2,33*		0,38	2,42*	1,99*	

$P < 0,05$

Table 6. The most important data of feed consumption

	Feed cons. g/hen/day 17	15	13	$\bar{X}$	ME kcal/hen/kg 17	15	13	$\bar{X}$	Protein g/hen/day 17	15	13	$\bar{X}$	Feed cons. kg/kg egg 17	15	13	$\bar{X}$
A Soya	132	128	125	129	324	316	309	316	22	18	16	19	3,31	3,32	3,30	3,31
B Pekilo	133	129	130	131	326	318	322	322	22	18	16	19	3,39	3,24	3,36	3,33
C Silva	131	132	129	131	322	325	319	322	21	19	16	19	3,25	3,28	3,34	3,30
$\bar{X}$	132	130	128		324	320	317		22	18	16		3,32	3,28	3,34	
	t_{A-B} 1,95	t_{17-15} 2,75xx											t_{A-B} 0,40	t_{17-15} 0,85		
	t_{A-C} 1,93	t_{17-13} 4,40xxx				xx P < 0,01							t_{A-C} 0,29	t_{17-13} 0,65		
	t_{B-C} 0,05	t_{15-13} 1,55				xxx P < 0,001							t_{B-C} 0,70	t_{15-13} 1,42		

Table 7. The results of the blood analysis

	n	Haemaglobin g/100 ml $\bar{X}$	Haemaglobin g/100 ml SD	Haematocrit % $\bar{X}$	Haematocrit % SD	In serum n	total protein g/l $\bar{X}$	total protein g/l SD	uric acid mg/100 ml $\bar{X}$	uric acid mg/100 ml SD	urea mg/100 ml $\bar{X}$	urea mg/100 ml SD
A Soya groups	24	12,1	2,3	31,4	3,4	17	46,4	2,6	4,21	1,33	9,11	3,58
B SCP- "	44	11,2	2,1	31,6	2,6	18	42,7	3,7	4,68	1,21	6,33	2,30
(Pekilo)	(22)	(11,4)		(31,7)								
(Silva)	(22)	(10,9)		(31,4)								
C Protein 17 %	24	13,1	2,0	30,5	3,2	12	44,7	2,9	5,33	1,13	8,66	1,45
D " 15 %	23	11,1	2,3	32,1	3,0	12	43,4	3,8	4,19	0,35	7,16	1,21
E " 13 %	21	10,1	0,9	32,1	2,2	11	45,5	4,3	3,78	0,99	7,18	3,54
t-values												
t_{A-B}		1,63		0,26			3,43^{xx}		1,09		2,74^{x}	
t_{C-E}		3,26^{xx}		1,70			0,89		2,37^{x}		1,09	
t_{C-E}		6,38^{xxx}		1,86			0,51		3,47^{xx}		1,04	
t_{D-E}		1,78		0,01			1,20		0,87		0,07	

Table 8. The specific weight and albumen quality of egg

	Spec. weight of egg 17	15	13	$\bar{X}$	n	Albumen height 17	15	13	$\bar{X}$	n	Haugh unit 17	15	13	$\bar{X}$	n
A Soya	1,080	1,080	1,079	1,080	221	6,61	6,19	6,61	6,60	329	81,0	77,5	81,1	79,8	329
B Pekilo	1,079	1,079	1,080	1,079	209	6,61	6,62	6,71	6,65	360	81,2	81,1	81,9	81,4	360
C Silva	1,079	1,079	1,079	1,079	250	6,51	6,71	6,38	6,54	374	80,2	83,1	78,6	80,6	374
$\bar{X}$	1,080	1,079	1,080			6,58	6,64	6,56			80,8	80,6	80,5		
n	222	230	228			354	366	343			354	366	343		

PEKILO-PROTEIN IN PRESTARTER AND STARTER FEED FOR CALVES REARED TO 120 DAYS OF AGE

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In this short report the results of an experiment on replacing skim milk powder with Pekilo-protein in feed mixtures for calves are presented.

Thirtytwo Lowland Black and White and Lowland Red and White calves (half of females and half of males), weighing approximately 59-63 kg, were assigned at 50 days of age to four different treatments. The calves were fed according to the daily feed allowance (table 2) meadow hay and prestrater or starter mixture containing different proportions of milk powder, feed yeast and Pekilo-protein (table 1). The calves were on trial until 120 days of age, then they were slaughtered and carcass traits were estimated.

At the begining and at the end of the experimental period in calves of each treatment the digestibility and N balance were estimated on the basis of data collected during two 7-day balance periods.

The results of the experiment are given in tables 3, 4, 5 and 6.

On the basis of the carried out experiment the following conclusions were drawn:

1. There was no adverse effect of Pekilo-protein when used up to 15 % in the prestarter, on feed palatability.

2. The calves fed Pekilo-protein based diets had superior daily gains as compared with the control group fed the diet without Pekilo-protein, although the differences were not significant.

3. The feed conversion was also improved when dried skim milk was replaced by Pekilo-protein in prestarter and starter mixtures.

4. Although the differences were not significant there was a tendency for better digestibility of nutrients in the calves fed Pekilo-protein based diets. The nitrogen retention was not affected by substitution of dried skim milk with Pekilo-protein in the diets.

5. There was no effect, when dried skim milk was replaced by Pekilo-protein, on slaughter characteristics or the health of the calves.

General conclusion:

The carried out experiment showed that Pekilo-protein can be considered as a valuable source of protein supplement in calves feeding.

Table 1. Percentage composition of the prestarter and starter mixtures used in feeding trial with calves. (Exp., June - October, 1977)

	Prestarter				Starter			
	1	2	3	4	1	2	3	4
Barley	31	31	31	31	61	61	61	61
Oat	6,30	7,70	9,00	10,50	3,56	4,35	5,08	5,93
Corn	10,0	10,0	10,0	10,0	5,66	5,66	5,66	5,66
Dried sugar beet	4,0	4,0	4,0	4,0	2,26	2,26	2,26	2,26
Soybean meal	15,0	15,0	15,0	15,0	8,6	8,6	8,6	8,6
Linseed meal	6,6	6,6	6,6	6,6	3,6	3,6	3,6	3,6
Skim milk powder	18,0	12,6	7,2	1,8	10,18	7,12	4,08	1,02
Pekilo	-	5,1	10,2	15,2	-	2,89	5,76	8,60
Feed yeast	3,5	2,4	1,4	0,3	1,98	1,36	0,80	0,17
Dehydr. grass meal	3,5	3,5	3,5	3,5	1,98	1,98	1,98	1,98
Premix+ minerals	2,1	2,1	2,1	2,1	1,18	1,18	1,18	1,18
In 1 kg:								
Crude prot. g	228	223	223	219	172	178	180	185
Oat units	1,08	1,10	1,10	1,12	1,15	1,14	1,12	1,10

Table 2. Daily feed allowance for calves in the experiment with Pekilo or skim milk powder in the diets.

Age (days)	kg/head/day Prestarter	Starter	Hay
51 - 60	1,6	-	1,0
61 - 70	1,9	-	1,0
71 - 80	-	2,0	1,0
81 - 90	-	2,2	1,2
91 -100	-	2,3	1,5
101 -110	-	2,5	1,8
111 -120	-	3,0	2,0

Table 3. Performance of calves fed dried skim milk or Pekilo-protein diets.

	TREATMENT (percentage in prestarter/finisher)			
Dried skim milk	18,0/10,18	12,6/7,12	7,2/4,08	1,8/1,02
Feed yeast	3,5/ 1,98	2,4/1,36	1,4/0,80	0,3/0,17
Pekilo	-	5,1/2,89	10,2/5,76	15,2/8,60
No. of calves	8	8	8	8
Daily gain (from 50 to 120 days), g	667	719	724	788
Feed conversion				
- kg dry matter/kg gain	3,31	3,05	3,07	2,80
- oat units/kg gain	3,86	3,49	3,44	2,99
- grams dig. prot./kg gain	498	468	468	428

Table 4. Digestibility (%) of nutrient in calves fed dried skim milk or Pekilo diets[x].

	TREATMENT (percentage in prestarter/finisher)			
Dried skim milk	18,0/10,18	12,6/7,12	7,2/4,08	1,8/1,02
Pekilo	-	5,1/2,89	10,2/5,76	15,2/8,60
Dry matter	71,53	74,51	75,61	74,11
Protein	71,17	73,60	75,39	72,04
Ether extract	67,51	68,07	65,71	61,58
Fibre	42,88	49,20	49,78	48,14
N-free extracts	80,23	82,26	82,55	82,45

x) Average of two 7-days balance periods.

Table 5. Nitrogen balance in calves fed dried skim milk or Pekilo diets.

	TREATMENT (percentage in prestarter/finisher)			
Dried skim milk	18,0/10,18	12,6/7,12	7,2/4,08	1,8/1,02
Pekilo	-	5,1/2,89	10,2/5,76	15,2/8,60
Daily N intake, g	80,13	77,74	78,51	77,65
N retained, g	36,08	37,08	34,48	33,37
N retained as a percentage of intake, %	45,02	47,69	43,92	42,97

Table 6. Slaughter analysis of calves fed dried skim milk or Pekilo diets.

	TREATMENT (percentage in prestarter/starter)			
Dried skim milk	18/10,18	12,6/7,12	7,2/4,08	1,8/1,02
Pekilo	-	5,1/2,89	10,2/5,76	15,2/8,6
Weight before slaughter, kg	110,25	111,00	106,50	117,00
Carcass weight (after chilling), kg	54,09	53,83	54,94	57,64
Dressing percentage, %	49,06	48,50	51,59	49,26
Meat in primal cuts[x], %	76,80	74,57	75,79	76,16
Fat in primal cuts, %	3,06	3,42	3,38	2,96
Loin eye area, cm^2	35,62	30,45	32,88	38,12
Fat iodine number	39,86	39,99	40,61	41,66
Protein in m. long. dorsi, %	19,97	20,18	20,28	20,54

x) Leg, fore ribs, best ribs, rump, round of beef

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Pekilo-protein in the calf starters

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Introduction

In Finland earliest Pekilo-protein feeding tests with little calves (LAMPILA et al. 1971,1972) were done with a pilot plant product (FORSS & JOKINEN 1972). The results obtained by LAMPILA et al. (1971) are briefly reviewed here. In the calf experiment done in Nautela's experimental station (Table 1), best growth and feed conversion rate was obtained with control calves and poorest results with the group receiving highest Pekilo-protein level in their diet. Poorer growth in Pekilo-groups was presumably due to lack of milk sugar. This fact was taken into the consideration when the diets for the second Pekilo experiment were designed. In the Pekilo-experiment done in Tikkurila, Pekilo-groups were quite equal to control group in respect of growth rate and feed conversion (Table 2). In this experiment, whey powder was added to the ration of Pekilo-calves.

HEIKKILÄ (1973) estimated digestibility of pilot plant Pekilo-protein by little calves. In her study digestibility of Pekilo organic matter was 71 % and digestibility of crude protein 75 % in 1-month-old calf.

When Pekilo-protein was prepared in larger amounts by Yhtyneet Paperitehtaat in Jämsänkoski's Pekilo-plant, further feeding and digestibility experiments were carried out with calves. KIISKINEN & KOSSILA (1977) tested Pekilo in three calf experiments in Jokioinen's Lintupaju and HOLMILA (1976) determined digestibility of Pekilo-containing calf starters in Department of Animal Husbandry, University of Helsinki.

Material and methods

Three calf experiments were carried out with Pekilo-protein in 1975 - 76.

Experiment 1. Two groups of 14 calves (9 AyAy ♂, 5 HfAy ♂) born in November-December in 1975, were fed with whole milk and industrial calf starter Maito-Maikki up to 4 weeks of age (Table 3). In addition, one group received dry control starter and another group dry Pekilo starter ad lib. up to 56 days of age. Composition of dry

starters are in Table 4. All calves received hay ad lib.

Experiment 2. 32 AyAy ♂ calves born in March-April 1976, were divided into two groups. Their feeding schedule is seen in Table 3, composition of control and Pekilo starters are in table 5, starters were fed in liquid form until 56 days of age. Oatmeal, grass silage and water, were available ad lib. Mineralmixture Selene was given at a rate of 50g/ animal/day. Also, A-,D-,E-vitamines plus Selenium was given to all calves by an injection. During last phase of the experiment blood samples were taken from 10 animals of each group. Determinations of hemoglobin (Hb) and hematocrit (Hc), were done at our laboratory. Serum total protein, albumin urea, urate, aspartateaminotransferase (ASAT) and alanineaminotransferase (ALAT) were done at the Yhtyneet Kliiniset Laboratoriot Oy.

Experiment 3. 8 AyAy and 6 FrAy male calves were fed control diet and 7 AyAy and 5 FrAy were fed Pekilo diet. As in Experiment 2, some of the calves were discarded because they were too old for the starter experiment. Therefore number of calves in different feeding groups is not similar. Calves were born in August 1976 and they were older at the beginning of the experiment 3 than in other experiments. Feeding schedule of calves is in Table 3 and composition of control and Pekilo diets in Table 5. All calves received oat meal and fresh grass ad lib. Otherwise management was similar to that of experiment 2. Statistical significance of the differences between calf groups was calculated using Tukey's test (STEEL & TORRIE 1960).

Results and discussion

Chemical composition of feeds used in the experiments 1, 2 and 3 are in Table 6. Growth rate, feed consumption and feed conversion of control and Pekilo-groups are in Table 7.

Experiment 1. Results in Table 7 indicate no significant differences between Pekilo and control groups. Daily gain of both groups was rather low perhaps due to early veaning and poor palatability of dry starter. Feces of calves in both group were quite soft but there was however no scours present.

Experiments 2 and 3. Results in Table 7 show, that in both, experiments 2 and 3, Pekilo groups gained significantly less weight and utilized

significantly more DM, FU and DCP per kg gain than control groups. Pekilo calves had more scours than controls. Blood and serum composition of controls was quite similar to that of Pekilo groups (Table 8), controls tended to hade somewhat higher Hb but lower urea ($P < 0.01$) and urate levels than Pekilo animals.

Post experimental growth. After Pekilo-experiments, animals were taken into further feeding experiments. Previous feeding was taken into account also when animals were regrouped for new experiments. Post experimental growth performance of calves of the experiments 1, 2 and 3 is shown in Table 9. There is not much differences in the rate of gain between control and Pekilo calves during 56 - 156 days of age.

Conclusions

Results indicate that Pekilo protein cannot fully replace skim milk powder in the diet of calves during the 4 first weeks of life. On the other hand after 4 weeks of age Pekilo + whey powder , which contains lactose, can replace at least part of the skim milk powder in calf diet, Similar findings were obtained when bacterial protein was fed to calves (KIISKINEN & KOSSILA 1976).
Relatively high incidence of scours suggests that small calves do not tolerate very well Pekilo-product.
Microbial proteins contain some nucleic acids, when they are metabolized in the body, uric acid is formed. Some uric acid is oxidized into allantoin which, in turn, is excreted from the body with urine. Pekilo fed calves had significantly more urea in their serum than controls.

Compared to the studies of LAMPILA et al. (1971,1972) the calves of the present experiments gained less and received much less milk proteins and also their starter feeding was finished earlier eg. 56 days vs. 84 days of age . Therefore in our study Pekilo protein was less promising compared to earlier results.
However it seems that Pekilo can be used in dry starters quite satisfactorily after 4 weeks of age. Moreover, growth during post starter period seemed not to be affected by the fact whether calves received Pekilo protein or did not receive it.

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Table 1. Gain, feed consumption and feed conversion of control and Pekilo fed Ay-male calves during 9 - 84 days of age. (Nautela 4)

Group	N	Live weight at end	Gain g/day	Feed consumption kg/animal WM	SKM	PEK	B	H	FU/kg gain
1	12	107	899	62	36	-	53	26	1.84
2	12	96	761	62	22	9	52	25	1.98
3	12	88	649	62	12	17	50	22	2.16
4	12	85	606	62	5	21	44	22	2.08

WM = whole milk
SKM = skim milk powder
PEK = Pekilo-protein
B = barley meal
H = hay, kg
Ay = Ayrshire
N = number of animals
FU = feed unit = 0.7 Starch equivalent

Table 2. Gain, feed consumption and feed conversion of control and Pekilo fed Ay-male calves during 12 - 84 days of age. (Tikkurila 1)

Group	N	Live weight at end	Gain g/day	Feed consumption kg/animal WM	SKM	PEK[1)]	B	H	FU/kg gain
1	9	98	843	52	36	-	62	18	2.21
2	9	99	847	54	18	24	53	19	2.10
3[2)]	9	98	839	52	-	46	53	19	2.26

1) Pekilo + whey powder-mixture (1:2)

2) Few calves in group 3 received on the average 5 liters sour milk during experiment

Table 3 . Feeding schedule of calves

Experiment 1.

Age days	Whole milk liters/day	Maito-Maikki[1] g/day	Water liters/day	Dry control or Pekilo starter	Hay
1- 6	4	-	-		
7- 9	2	300	2	ad lib.	ad lib.
10-28	-	600	4		

1) Maito-Maikki is an industrial calf starter which is mixed with water. Its composition is: Skim milk powder 50, whey powder 10, fodderyeast 3, soymeal 6, linseed meal 1, fat 16, grass meal 11,5, dicalcium phosphate 0,8, NaCl 0,18, vitamin premix 1,5 % plus trace element salts.

Experiments 2 and 3.

Age weeks	Whole milk liters/day	Control[1] starter g/day	Pekilo[1] starter g/day	Water, liters	Silage (Grass)	Oat meal
1.	4	-	-	-	-	-
2.-7.	-	600	630(625)[2]	4	ad	ad
8.	-	300	315(310)	2	lib.	lib.
DP kg		5.3	5.4 (5.4)			
DE Mcal		128.2	129.4 (131.0)			

1) Diluted with water

2) (Experiment 3)

Table 4. Composition of dry starter mixtures in experiment 1.

Component	Control	Pekilo
	%	%
Skim milk powder	25	-
Whey powder	10	25
Pekilo protein [1]	-	17
Soymeal	15	15
Barley	25	20
Oat	12	10
Molasses beetpulp	10	10
Mineral mixture [2]	2.5	2.5
Vitamin " [3]	0.5	0.5
DCP, %	19.1	18.2

1) Ground through 1 mm ø sieve. Chemical composition of Pekilo: DM 93.8, CP 47.2, CF 1.4, NFE 31.7, CFiber 8.1, ash 5.4%.

2) Viher-Terki: P 9.0, Ca 13.5, NaCl 24, Mg 5 % plus trace-elements and vitamin D_3 40 000 iu/kg.

3) DEB-KARJAVITA: Vitamin A 1.6 mill. iu/kg, vitamin D_3 600 000 iu/kg, vitamin E 1000 mg/kg.

Abbrevations:
FU = feed unit = 0.7 starch equivalent
DM = dry matter
CP = crude protein
DCP = digestible crude protein
CF = crude fat
CFiber = crude fiber
DE = digestible energy
NFE = nitrogen free extract

Table 5. Composition of the starters diluted with water in experiments 2 and 3.

Component	Experiment 2		Experiment 3	
	Control	Pekilo	Control	Pekilo
Skim milk powder	53.0	30.0	53.0	40.0
Whey powder	25.4	30.4	25.3	28.0
Pekilo protein 1)	-	18.0	-	10.0
Fat mixture 2)	20.0	20.0	20.0	20.3
Calculated values: 3)				
DE kcal/kg	4715	4510	4715	4615
DCP, %	19.6	18.9	19.6	19.1
Pekilo, & of total DCP	-	32.5	-	18.0

Each mixture contained 1.0 % dicalciumphosphate, 0.2 5 NaCl and 0.4 % trace-element salts and vitamines (Premix of Vaasan Höyrymylly).

1) Pekilo was ground through o.5 mm ø sieve. Chemical composition of Pekilo was: DM 95.3, CP 46.7, CF 46.7, CF 1.2, NFE 33.3, CFiber 9.2, ash 4.9 %
2) Mainly animal fat, mixed by Vaasan Höyrymylly
3) Following values were used in the calculations:

	DP, %	DE, kcal/kg
Skim milk powder	32.0	3850
Whey powder	10.4	3450
Pekilo protein	34.0	2800
Fat mixture	-	9000

Table 6. Chemical composition and feed value of feeds used in the experiments 1, 2 and 3

	Experiment 1.					Experiment 2.					Experiment 3.				
	Whole milk	Maito Maikki	Control Starter	Pekilo Starter	Hay	Whole milk	Control Starter	Pekilo Starter	Oat meal	Silage	Whole milk	Control Starter	Pekilo Starter	Oat meal	Grass
DM, %	12,80	92,73	89,92	90,39	81,58	12,80	93,84	93,83	88,14	29,31	12,80	93,16	93,39	87,56	28,30
In DM, %:															
CP	26,79	28,96	24,80	25,12	9,54	26,79	24,22	24,89	12,65	17,18	26,79	22,64	24,17	14,15	14,06
CF	33,92	16,05	1,29	1,52	2,14	33,92	17,88	19,20	4,85	5,01	33,92	20,32	20,65	5,55	3,52
NFE	32,59	42,50	60,98	58,58	49,12	32,59	49,56	46,25	68,12	41,26	32,59	49,04	46,61	67,99	49,38
C Fiber	-	4,84	4,90	6,86	30,33	-	0,26	2,16	8,84	25,46	-	0,31	1,26	9,02	22,85
Ash	6,71	7,65	8,03	7,92	8,87	6,71	8,08	7,51	5,33	11,10	6,71	7,69	7,31	3,29	10,19
Kg/FU	3,98	0,78	1,04	1,07	2,15	3,98	0,70	0,71	1,02	5,05	3,98	0,69	0,70	1,05	4,54
Kg DM/FU	0,51	0,72	0,93	0,97	1,75	0,51	0,66	0,67	0,90	1,48	0,51	0,64	0,65	0,93	1,25
DCP %	3,09	24,17	19,85	19,76	4,75	3,09	20,91	19,85	9,15	3,62	3,09	18,98	19,41	9,29	2,81
DCP g/FU	123	189	207	212	102	123	147	142	94	183	123	131	137	99	123

Starters in experiment 1 were fed as dry and in experiments 2 and 3 as diluted with water

Table 7 . Growth rate, feed consumption and feed conversion of control and Pekilo groups of calves in the experiments 1, 2 and 3

Experiment 1. Calves between 0-56 days of age.

Group	N	Live weight, kg at start	at end	Gain kg	g/day	Feed consumption, DM,kg/animal Whole milk	Maito-Maikki	Starter mixture	Hay	Total	DM/kg gain	FU/kg gain	Digestible crude protein g/day/calf	g/kg gain	g/FU
Control	14	36,8	58,3	21,5	384	4,16	11,14	27,06	8,46	50,82	2,36	2,66	187	486	183
Pekilo	14	38,1	61,7	23,6	422	4,25	11,17	30,92	10,06	56,40	2,39	2,59	201	477	184

Experiment 2. Calves between 0-56 days of age

Group	N	Live weight, kg at start	at end	Gain kg	g/day	Feed consumption, DM,kg/animal Whole milk	Starter mixture	Oat meal	Silage	Total	DM/kg gain	FU/kg gain	Digestible crude protein g/day/calf	g/kg gain	g/FU
Control	17	37,9	76,1	$38,2^{b}$	682^{b}	4,86	23,45	14,88	14,55	57,74	$1,56^{a}$	$1,93^{a}$	173	262^{a}	136
Pekilo	15	37,2	66,1	$28,9^{a}$	516^{a}	5,41	24,88	11,99	13,11	55,34	$1,91^{b}$	$2,40^{b}$	167	324^{b}	135

Experiment 3. Calves between 14-56 days of age

Group	N	Live weight, kg at start	at end	Gain kg	g/day	Feed consumption, DM,kg/animal Whole milk	Starter mixture	Oat meal	Grass	Total	DM/kg gain	FU/kg gain	Digestible crude protein g/day/calf	g/kg gain	g/FU
Control	14	43,9	70,7	$26,9^{b}$	640^{b}	0,21	21,20	16,11	7,10	44,63	$1,70^{c}$	$2,16^{c}$	162	260^{a}	120
Pekilo	14	43,5	63,6	$20,1^{a}$	478^{a}	0,11	22,47	13,46	7,57	43,67	$2,35^{d}$	$2,99^{d}$	164	373^{b}	125

$a < b = P < 0,01$, $c < d = P < 0,05$

Table 8. Composition of blood (serum) of calves in experiments 2 and 3.

Component	Experiment 2 Control (N=10)	Experiment 2 Pekilo (N=10)	Experiment 3 Control (N=10)	Experiment 3 Pekilo (N=10)
Blood:				
Hb g/100 ml	10,5 ± 1,3	9,9 ± 2,1	9,8 ± 1,6	9,5 ± 1,1
Hc, %	32,2 + 3,1	34,8 ± 3,9	35,8 ± 5,5	33,7 ± 3,2
Serum:				
Tot. prot. g/l	54,8 ± 2,1	53,1 ± 4,2	—	—
Albumin g/l	31,0 ± 2,2	29,0 ± 2,1	—	—
Urea mmol/l	2,43± 0,69[a]	3,71± 0,85[b]	—	—
Urate mmol/l	38,0 ± 11,1	44,5 ± 12,1	—	—
ASAT m/l (37°C)	66,3 ± 11,2	62,5 ± 14,1	—	—
ALAT ml/l(37°C)	16,5 ± 2,6	17,4 ± 4,3	—	—

a < b = P < 0,01

Table 9. Post experimental growth performance of control and Pekilo calves.

	Control	Pekilo
Exp. 1.	(N=14)	(N=13)
Live wt at 56 days of age	58,3	60,9
" " " 156 " " "	145,0	156,0
Gain g/day between 56-156 days	867,0	951,0
Exp. 2.	(N=17)	(N=14)
Live wt at 56 days of age	76,1	66,7
" " " 156 " " "	180,4	168,0
Gain g/day between 56-156 days	1043	1013
Exp. 3.	(N=14)	(N=12)
Live wt at 56 days of age	70,7	63,6
" " " 156 " " "	157,6	149,0
Gain g/day between 56-156 days	869	854

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