Vethellas
ANIMAL HEALTH

4 ΣΥΜΠΟΣΙΟ ΧΟΙΡΟΤΡΟΦΙΑΣ

СИМПОЗИУМ ПО СВИНОВОДСТВУ

SYMPOSIUM OF SWINE PRODUCTION

23 & 24
ΣΕΠΤΕΜΒΡΙΟΥ
2016

Πλαταμώνας
ΕΛΛΑΔΑ

Платамон
ГРЕЦИЯ

23 & 24
Сентября
2016

Platamon
GREECE

23 & 24
SEPTEMBER
2016

Vethellas
ANIMAL HEALTH

1986 30 YEARS 2016

Table of
Contents

4th Symposium of Swine Production

PHARMACEUTICAL SUPPLEMENT

MOXAVET®

WATER SOLUBLE POWDER FOR ORAL ADMINISTRATION

Vethellas

...Planning the future of animal farming...

GREETING

Celebrating 30 years from VETHELLAS establishment and its successful and prosperous business activities, I am pleased to welcome you to the 4th Symposium of Swine Production we organize.

In a time when economic context in Greece is not favorable for the development of enterprises, we must not forget that the way-out may be the openness to the markets and the implementation of a policy that promotes the improvement and the development of know-how.

Aiming at the development of scientific research in the field of animal husbandry, VETHELLAS has the honor to present to you the speakers of this Symposium, Greek and foreigner distinguished scientists, specialized in the field of animal nutrition, animal health and genetic improvement of pigs.

VETHELLAS is committed to put all its efforts in order to support animal husbandry in Greece and all those who work in this sector and provide the optimum proposals regarding animal nutrition, based on the most recent scientific findings.

The company guarantees the above, given its modern and certified production infrastructure, dedicated to the production of nutritional and pharmaceutical products, as well as the new chemical and microbiological laboratory, under construction, in the Industrial Area of Larissa. This investment, will cover the needs of VETHELLAS Quality Control Department for the performance of the analyses of the raw materials and final products.

Kachrimanidis Angelos
President and C.E.O of Vethellas S.A.

TRIMETHOPRIM SULPHADIAZINE 30% VETHELLAS

The ideal synergy

Vethellas
...Planning the future of animal farming...

INTRODUCTION

This year, VETHELLAS celebrates its 30th anniversary from its establishment in 1986, under the name of VETHELLAS – Angelos Kachrimanidis and Co. Ltd. Within this long period the company had a continuous and successful presence in the markets.
The significant development and growth of the enterprise over these years, resulted to the present structure of VETHELLAS Group of companies.

By choosing and implementing a business practice aiming at the satisfaction of our customers, we continuously improve our products and services offered, we face dynamically the emerging challenges in the field of animal husbandry in Greece and abroad and we never cease to evolve and expand our business activities.

Vethellas group of companies, a group solely of Greek interests, consists of companies operating in Greece and abroad, covering the full range of needs of modern animal farming.

The group consists of companies, each of them specializing in a particular business sector.

More specifically, Vethellas group of companies supplies a wide range of services which include:

- Production and trading of veterinary nutritional products and veterinary medicines of high standards.
- Production of sows & boars of high genetical value as well as F1 lines and terminal boars.
- Providing scientific support in nutrition issues.
- Managing of livestock units.
- Preparation of business plans.
- Modernization, construction and supply of mechanical equipment for livestock units.

BRIEF PRESENTATION OF COMPANIES

VETHELLAS S.A.

Vethellas S.A., specializes in the production and trading of veterinary nutritional products (premixes, complementary feed (balancers), feed additives), as well as in the production and trading of veterinary pharmaceutical products. Additionally, it provides consulting services to swine and poultry units by formulating and supporting nutritional programs and by supervising the management of the relevant units.

Vethellas has modern industrial facilities with fully automated operation via electronic system, for the control and monitoring of the production process at all stages. Its facilities meet all the requirements of the European legislation and the production process is approved and certified by Greek and European Organizations as for the production of a wide range of nutritional and pharmaceutical veterinary products, according to the modern international standards (ISO 9001:2008, Good Manufacturing Practice- GMP-, HACCP).

At the same time, both raw materials and finished products are checked thoroughly by the Quality Control department by performing chemical and other analyses to ascertain the achievement of the quality objectives and the compliance with the established specifications.

Vethellas, aiming mostly at the production of high quality products, has already begun the construction of a new chemical and microbiological laboratory, a totally new building, to house the Quality Control Department.

GENNITOR S.A

Gennitor S.A. is a member of Vethellas group of companies, which based on the continuous genetic improvement, produces swine of high standards to cover the needs of greek and international market, where the group is active.

The company owns two swine units with a total capacity of 1350 sows. This can be estimated in an annual production of 30.000 pigs per year.

The company's investment, research, animal husbandry and genetic activities are focused on those productive targets which ensure the highest profit to the breeder as well as the supply of all zootechnical, scientific, technical and managerial services to the swine units, in a manner that our customers will achieve a production of:

- 22 piglets per sow, per year to the slaughterhouse.
- Decrease of the slaughter time to 140-150 days for swine of 105 kg live weight.
- Improvement of the feed conversion rate to 2,3.

ROSVET KUBAN

Rosvet Kuban Ltd, is Vethellas' affiliated company and its role is to distribute Vethellas' products in Russia.

The main activity of the company is the supply of Russian livestock enterprises, with high quality nutritional and pharmaceutical products (premixes and w/s) for swine, poultry and cattle, as well as with final feed and concentrates for swine and poultry.

The company offers a wide range of products suitable for livestock use, with main feature the capability to adjust their participation in the final feed, depending on the nutritional needs of animals in each farm, providing flexibility in the preparation of ratios.

INTERAGRO LTD

Interagro Ltd is the youngest member of the group and is engaged in the development and the modernization of swine units, import of the art equipment, automatic feeding systems, ventilation and cooling, drainage and other equipment for the proper and complete function of these units.

The company adjusts the selection of equipment to the financial requirements of each customer and provides all necessary guarantees for the proper installation and operation of the systems and equipment provided.

All proposals are driven by the high performance of the equipment, which is ensured by the introduction of advanced European technology machinery destined to swine production and breeding.

The entire installation process and the monitoring of technology compliance is made by specialists of our own company.

Vethellas®

GENNITOR®

www.vethellas.gr

ИНТЕРАГРО

РОСВЕТ КУБАНЬ

PRODUCTS

Vethellas emphasizes in the continuous improvement of its products, based on the modern scientific data as well as on the extensive practical experience accumulated over the years.

Our primary goal is to deal with the specific needs of each unit in the field of nutrition, taking into consideration the technical capabilities of each producer.

Vethellas S.A. produces :

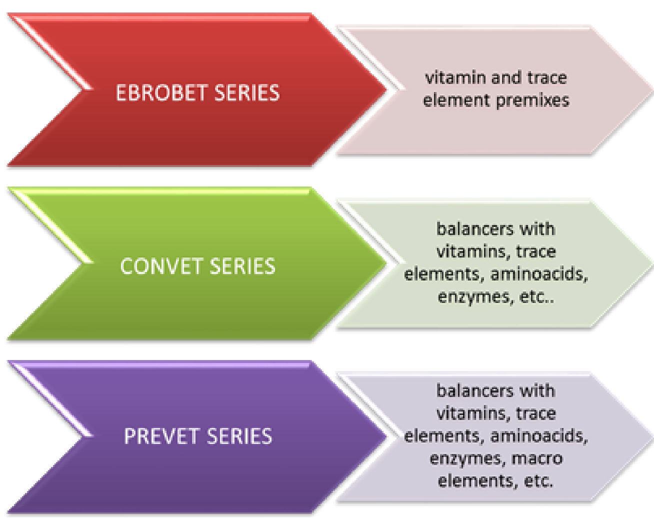
- **EBPOBET** product range (vitamin and trace elements premixes).

Satisfies the requirements for vitamins and trace elements of each animal category, based on the needs of modern genetically improved pigs and poultry (broilers and layers).

- **CONVET** product range (balancers with vitamins, trace elements, aminoacids, enzymes, etc.).

Satisfies the requirements for vitamins, trace elements, amino acids, etc of each animal category, based on the needs of modern genetically improved pigs and poultry (broilers and layers).

- **PREVET** product range (balancers with vitamins, trace elements, aminoacids, enzymes, macro elements, etc.).



Summary table of nutritional products

RANGE	PRODUCT	DESCRIPTION
EBROBET	EBROBET 2C VIT	Vitamin premix for piglets
	EBROBET 3C VIT	Vitamin premix for pre-fattening and fattening pigs
	EBROBET 4C VIT	Vitamin premix for sows
	EBROBET 2C MIN	Trace elements premix for piglets
	EBROBET 3C MIN	Trace elements premix for pre-fattening and fattening pigs
	EBROBET 4C MIN	Vitamin premix for sows
	EBROBET 1B VIT	Vitamin premix for broilers of all ages
	EBROBET 1K VIT	Vitamin premix for layers.
	EBROBET 1B MIN	Trace elements premix for broilers of all ages
	EBROBET 1K MIN	Trace elements premix for layers.
CONVET	CONVET 1	Balancer for piglets for ratios that may contain all kind of cereals.
	CONVET 2	Balancer for pre-fattening and fattening pigs
	CONVET 3	Balancer for sows
	CONVET 1K	Balancer for layers
	CONVET 2K	Balancer for poultry
	CONVET 1B	Balancer for broilers for the starter diets
	CONVET 2B	Balancer for broilers for the fattening and growing period
PREVET	PREVET PIGLETS CORN 2.5%	Balancer for piglets especially made for corn based diets
	PREVET FATTENING H.A. CORN 1.5%	Balancers for pre-fattening and fattening pigs especially made for corn based diets
	PREVET SOWS CORN 2.5%	Balancer for sows especially made for corn based diets
	PREVET PIGLETS CORN + WHEAT 2.5%	Balancer for pigs especially made for corn-wheat based diets
	PREVET FATTENING H.A.WHEAT 1.5%	Balancers for pre-fattening and fattening pigs especially made for wheat based diets
	PREVET SOWS WHEAT 2.5%	Balancer for sows especially made for wheat based diets
	CONCENTRATE PREVET	Proteins concentrate for piglets
	PREVET LAYER 1	Balancer for layers of 1 to 18 weeks of age.
	PREVET LAYER2	Balancer for layers of 18 to 65 weeks of age.
	PREVET BROILER 1	Balancer for broilers for the starter diets
	PREVET BROILER 2	Balancer for broilers for the fattening and growing period
HYDROL	HYDROL	Water solulbe powder for treating dehydration due to diarrhea and for the establishment of the electrolytic balance in pigs.

CUSTOMIZED PRODUCTS

Vethellas S.A. can produce any customized product, adaptable in various ratios, according to the customer's enquiry. Furthermore, we can design, test and develop specific products in line with the needs of each breeder (customized-new product development).

PHARMACEUTICAL PRODUCTS

- Additionally, Vethellas S.A is producing pharmaceutical products of high quality, according to Good Manufacturing Practice (GMP), in the form of premixes for medicated feed and water soluble powders.

TRADE NAME	ACTIVE SUBSTANCE
PECIVET	**Penicillin V Potassium 10%**
MOXAVET	**Amoxicillin Trihydrate 80%**
CLAVAVET	**Doxycycline Hyclate 50%**
MULIVET	**Tiamulin Hydrogen Fumarate 2%**
MULIVET 45% w.s.p.	**Tiamulin Hydrogen Fumarate 45%**
SPECLIN	**22,20 % Lincomycin (base) , 44,5 % Spectinomycin (base).**
VETCYCLINE	**Chlortetracycline HCl 10%**
TRIMETHOPRIM-SULFADIAZINE 30% VETHELLAS	**Trimethoprim 5%, Sulphadiazine 25%**
TRIMETHOPRIM-SULFADIAZINE 50% VETHELLAS	**Trimethoprim 8,33%, Sulphadiazine 41,67%**
OXYTETRACYCLINE 50% VETHELLAS	**Oxytetracycline Hydrochloride 50%**
AMOXICILLIN-CLAVULANIC ACID VETHELLAS	**Amoxicillin (trihydrate) 10%, Clavulanic acid (as potassium salt) 2.5%.**
LINACIVET	**Oxolinic Acid 50%**

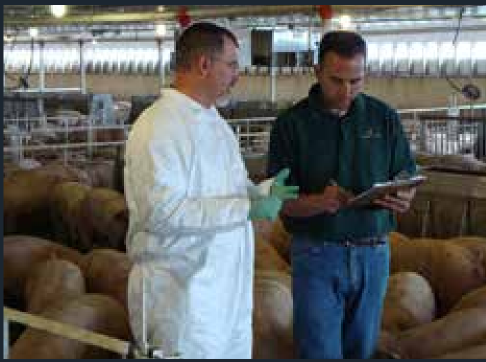
PECIVET®
Premix

The only orally administered
Penicillin

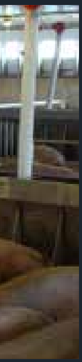
Vethellas
...Planning the future of animal farming...

COMPETITIVE ADVANTAGES OF THE GROUP

- We don't omit to monitor the ongoing changes, improvements and claims arising in the zootechnical and scientific level, in order to adapt our products accordingly.
- Linked to the above objective is the Research and Development (R&D) department, which is in constant research of scientific alternatives for even greater satisfaction of our customers' needs.
- Cooperation with Universities and National Institutions, to conduct scientific experiments under the guidance and the supervision of veterinarians and animal husbandry experts, in order to ensure the results validity for the benefit of our customers.
- Therefore, any optimization proposal we make, is completely tested for its performance effects and thus profitable for our customers.
- We offer technical support and after-sales service. The specialized personnel of our company (veterinarians – animal husbandry experts) offers consulting, as well as monitoring services at production, technical and managerial level. This is interpreted by direct and regular contact with the businessman-breeder, in order to settle all the problems that may arise.
- Vethellas Group of companies is an one stop buy solution. Our company covers the entire spectrum of modern animal farming, starting from the preparation of the business plan up to the operation of the livestock facilities, providing full technical support. Our company also undertakes the zootechnical management, the preparation of nutritional programs and pharmaceutical treatments, as well as the supply of nutritional and pharmaceutical products. All these contribute to the maximum synergy among the products and the services provided by the Group, which result in the achievement of the maximum productivity and the optimal financial outcome for our customers.



Planning the future of modern animal farming



Genetically Improving the Pig from 1960-2016

John Millard

CEO of J J Genetics, England

Thank you to Angelos Kachrimanidis and all at Vethellas for inviting me to the 4th Symposium of Swine Production and thank you for all your good hospitality, business and comradeship over the past 24 years.

First and foremost, I am a farmer who has found I have the ability to improve breeding pigs, I am not a professor. I have exported breeding pigs to 58 countries to improve their pigs genetics. In this presentation, I will be discussing the changes we have seen in the pig over the last 56 years and the strategies I have used in my own breeding programmes by combining the art and science of genetic improvement. It has been our goal to produce a pig that is economically improved, but is also easy to manage across the world. I will look at the results I have achieved and the success reported by my customers. If I had another life, I would love to breed racehorses and correct the racehorse breeding policies.

The improvements in the pig have been dramatic; in 2010 1kg of feed produces 2.7 times more lean meat than it did in 1960. Pigs grow faster and feed conversion ratio (FCR) has improved from 3.2 to 2.3. We have seen changes in the carcass composition with the lean meat percentage improving from 48% to 63%.

These genetic improvements have been driven by the goal of producing more lean meat at a lower cost and increasing financial rewards:

- Increase Lean Meat Percentage
- Improve Growth Rate
- Improve Litter Numbers Born
- Improve Litter Numbers Reared (piglets/sow/year)
- Improve Longevity of the Sow

The Pig improvement Revolution

We have seen the pig improvement revolution spread across the world and this has tied into the pattern of international export of our pigs.

1950 UK, Denmark, France, Holland, Norway, Sweden & Finland

1965 Eastern Europe, Hungary, Poland, Czech Republic, Greece

1975 Asia, Thailand, Phillipines, Korea,

Canada, USA, Russia

1985 Vietnam

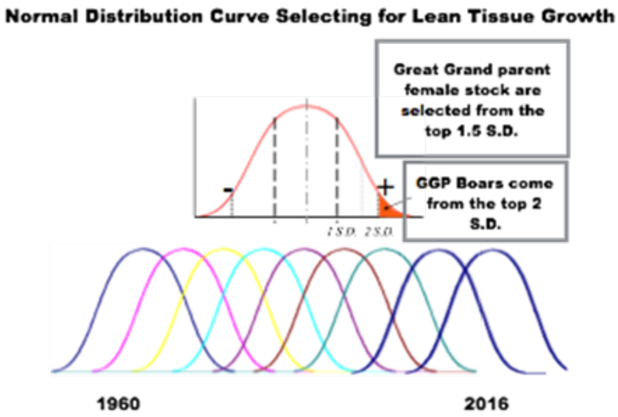
2000 China

2015 Africa

Note that 50% of the world's pigs are in China and in 2014 only 18% of their pigs were a modern breed. Our modern pig only eats 60% of the food that the old fashioned Chinese pig eats to reach bacon weight (100kg live weight). Therefore, if all the pigs in China were modern, there would be a 12% surplus of soya bean meal in the world and a 12% surplus of cereals.

UK Central Testing Scheme

The UK has an history of exporting breeding stock to improve the world's livestock, including cattle, pigs, sheep and racehorses. A scheme to improve the national herd by The Pig Industry Development Authority (later the Meat and Livestock Commission) ran Central Testing Stations to test pigs on performance and carcass composition. About 300 pedigree herds were involved in the testing scheme and in 1963 my herd was one of the top tested herds. Best performing boars could then be used by AI stations, other breeders and exported abroad for breed improvement. This selection along with the performance data gathered, facilitated rapid improvement in carcass quality and growth rate. Later, on-farm testing and ultrasonic back fat testing took over from Central Testing Stations mainly because of Biosecurity.



In our herd we also changed the shape of the pig to improve ham shape, particularly in the case of the Large White, we increased the ham and loin and reduced the shoulder and belly.

Dangers of Single and Dual Trait Selection

Whilst all genetic improvement was focused on rapidly improving the lean tissue growth rate, many pig breeders did not also select for some fundamental traits of the pig. We have seen the dangers of single and dual trait selection across the livestock breeding industry. We can look at the Canadian Holstein as an example, heavily genetically selected for milk yield and butterfat but not selected for longevity or conformation and as a result the highest yielding cows are unable to average two lactations.

Keeping the Pig Functional and Balanced

We need to breed pigs that will improve lean tissue growth rate but most importantly, ensure we are breeding a pig that will be functional, balanced and easy to manage. I will describe the other areas I have focused on in my breeding programmes, to ensure we breed an animal for the future that is easy to manage.

1. **Teats** - Some major breeding companies have not improved and selected for the number and shape of teats. It is no use having 18 pigs born if your sows only have 12 nipples. Shape and spacing are so important, the piglet must be able to get the nipple into its mouth easily and suckle the milk. Nucleus herds should cull any gilts or boars without correctly shaped teats and numbers of teats.

2. **Legs** - Our modern pigs need strong legs with thick bones and strong even feet to carry the extra muscle of the modern pigs. I select for strong

pasterns that have some spring in them, especially as most of today's pigs live on concrete. Pigs should be selected for good locomotion with a leg on each corner for good stability.

3. **Reduce Abnormalities** - Nucleus herds should record abnormalities, hernias and blind anus and reduce these abnormalities by culling sows that produce hernias, and culling boars that produce more than 1 in 500. Some of our Duroc Boars were placed on an AI stud in Denmark, our boars' progeny reduced the percentage of hernias in their progeny by over 80%.

4. **Fertility** - I have met some farmers in Europe who only get 75% of gilts pregnant at the first mating, that costs a lot of money. I would advise to only keep Great Grand Parent (GGP) sows that become pregnant easily on the first mating, and by doing this, we have improved the conception rate on first mating on F1 gilts from 85% to 99% during the last 50 years.

5. **Stress** - We still test all the young boars for Porcine Stress Syndrome, and only keep the negative boars, to ensure we do not have stress in our herd. With this selection, we have lost a little bit of extreme ham shape, but we do NOT have any problems with pigs dropping dead during transport.

6. **Selection Rate** - The selection rate on our F1 gilts has gone up from 28% to 85% over the last 50 years because we have improved the teat shape and numbers and corrected the feet shape. We used to cull 40% of our gilts for poor teats alone, now due to improvements, it is only about 5% plus we have improved the leg and feet so much over 50 years.

7. **Embryo Survival** - During my lifetime, numbers born alive in the Large White Breed have increased by three piglets. Reducing embryo death is the key to increasing numbers born. In 1986 - 1988 we were transferring embryos from High Genetics to High Health Sows, to upgrade the genetics in a high health herd. Five days after ovulation, we had an average of 29 embryos fertilised but only 12 pigs born alive. From this data, we concluded that fertilisation was not a problem, but that embryo survival was limiting numbers born. Nine days after fertilisation the embryos embed into the uterus and stretch out to 150mm long, if there was not a clear space the embryos just drop off, creating embryo loss. It is also noted that longer sows have longer uteruses and therefore more piglets born. We had observed that for many years, before we knew the scientific reason why. The conclusion is that with correct management and diet, fertilisation is not a problem affecting number born, instead embryo survival is the key. Our

customers with very small herds, 2 - 10, sows get incredibly high numbers born. I met a customer this summer who has Large White sows averaging over 20 born after the first litter! I put this down to these sows not getting knocked about by other sows, and therefore, they lose very few embryos in pregnancy.

The result of good teat shape, high teat numbers, strong legs, good fertility, reduced stress and higher selection rates makes the pigs EASIER TO MANAGE.

Customer Success

Over the years my exported breeding stock has improved herds around the world. Here are a few success stories reported by my customers.

- Holland - Ren Van As says '500 weaner pigs from my pigs 495 will grow quickly to slaughter weight, and no other company's pigs grow as quickly'. He says he can buy weaners from one of my big European competitors and only 400 out of 500 grow on to slaughter weight quickly, the other 100 pigs take one to two months longer. The difference in results is mainly because that company only selects for leanness, and numbers born and relies heavily on a Best Linear Unbiased Prediction (BLUP) programme and does not select enough for important other traits.

In my opinion, BLUP is a very good genetic improvement programme and particularly on the maternal side. But if you let BLUP dominate, it will eventually lead to inbreeding, an increase in abnormalities, lower conception and poorer conformation. To be a good pig breeder, you have to be ruthless and cull out the bad pigs and not keep pigs with faults and maintain heterosis. Along with high numbers born, we need to have good strong, durable pigs that all grow evenly and quickly from weaning to slaughter weight.

- Thailand - In the nineties we improved the numbers reared in a 3,000 sow herd by 1.6 kgs per litter.
- USA - With Shaffers Superior Genetics we improved their carcass quality to be recognised as the best carcass quality in the Mid West.
- Korea - In the nineties our customer Mr Choi broke the growth rate record in the Korean Testing Station.
- China - A group in Chongqing made big improvements to their nucleus herd, shown in the table below.

	PREVIOUS	JJ GENETICS
ADG (grams)	720	910
FCR	3.20	2.55
Numbers Born Alive	9.3	11.2

- Ghana - Jason Adu Gyamfi found growth rate improved massively. Reducing days to 100kg from 455 days to 138 days.

Utilising Breed Qualities

In breeding programmes it is important to utilise the qualities that each breed has to offer.

- Large White or Yorkshire - The faster growing pig that grows lean meat the fastest, it must be 25 - 50% of every commercial programme. Our Large White Breed has been divided into Dam Lines and Meat Lines.

- Landrace Welsh - We mainly use Welsh Landrace and it should be 50% of every female. The advantages of Welsh Landrace in comparison to English Landrace is that she produces more milk, has stronger legs and feet, extra litters in a lifetime, improved durability and rears more pigs per year.

- Duroc - is a very good producer of terminal meat pigs, but a poor mother. The qualities of this breed are: fast growing, disease resistant, durable pigs and marbling in the meat to improve taste. There is a higher response for crossbreeding than any other breed. The progeny of our Duroc boars are much less aggressive in the growing stages and most unlikely to fight or tail bite.

Heterosis - Cross Breeding

Our breeding programmes take the heritable traits of the Pedigree pigs and produce a pig that has a combination of these desirable qualities. The result of heterosis is a pig that has more piglets born and reared, faster growth, fewer abnormalities, more disease resistance and stronger legs. What is the importance of using pure pedigree pigs? By using the pure pedigree pigs you will achieve the highest heterosis in comparison to using lines which are made up of various breeds and therefore don't achieve the same level of heterosis. The genetic improvement has to be achieved in the purebred herds, and then cross to produce commercial pigs. The F1 gilt will produce an extra 3.2 pigs per year more than their pedigree parents.

Nutrition

It is very important that, whilst all these improvements are being made to the pig, nutrition is also improved to take advantage of the advancements. The improved pig will require an increase in the density of the pig feed, in particular the amino acids, minerals and vitamins, as well as energy. I believe that milk and fishmeal contain micro ingredients that have not been discovered yet, as lean tissue growth rate responds rapidly to these feeds.

High Health

We obtained our High Health Status using a Segregated Early Weaning (SEW) programme. In a diseased herd the sow has developed immunity to the diseases present and transfers this immunity to the piglets via colostrum and antibodies in her milk. However, when the piglets immunity received from the colostrum is reduced, the piglets become susceptible to diseases in the herd and they get infected by older pigs and by the sow. For example, at 5 days old, the piglets become susceptible to Strep Meningitis and at 12 days old, they become susceptible to Mycoplasma Pneumonia.

SEW works, because the piglets are weaned before they are 120 hours old, while still protected by the antibodies in the mothers colostrum and transferred to a disease free environment, over three kilometers away from other pigs. A disease free herd, which is also free of parasites, can be developed from these piglets.

Future Developments

In the future, I expect that we will continue to see big improvements in daily live weight gain, an increase in pigs reared naturally, and an improvement in taste. For more pigs to be reared naturally, we will need to continue to select for high teat numbers, improve the management of the sow during pregnancy, to minimise loss of embryos and improve the milking potential of the sow.

There is potential for a big increase to be seen in the daily live weight gain. Daily gain is still increasing 8-10 grams per pig per day. The best pigs are achieving an average of over 1 kilogram daily gain, with the very best individual pigs growing at over 1.5 kg a day, from 20 - 120 kilograms with the possibility of this rising to over 2 kgs per day in the future. With these improvements it will be very important to have a good skeleton, strong legs and foot strength to support that fantastic average daily gain. I expect to see continued selection to increase the number of litters a sow has in her lifetime and additionally an improvement in the taste of the meat with more marbling.

Antibiotics in animal production: Problems and Alternatives

Alexander N. Panin,

Academician of the Russian Academy of Sciences

Member of the French Academy of Veterinary Medicine

Member of the working group on the safety of livestock products of the World Organization for Animal Health (OIE)

INTRODUCTION

The World population throughout the centuries is increasing rapidly.

More specifically, while in 1500 the world population was 500 million people, in 1800 reached 1 billion, in 1900 1.65 billion while in 2013 seven billion people are living on the planet.

CHRONOLOGY	WORLD POPULATION
1500	500.000.000
1800	1.000.000.000
1900	1.650.000.000
2013	7.000.000.000

The trend of increasing world population in combination with medical recommendations for human nutrition, leads to a projection for an increased consumption of animal protein by humans of about 50% by 2020.

This increase will bring to scientists around the world, a number of challenges. One of these is the improvement and development of new tools for the prevention and treatment of animal diseases, with the aim of increasing production.

USE OF ANTIBIOTICS IN LIVESTOCK PRODUCTION.

Antibiotics in livestock production are used for:

- Treatment against diseases
- Prevention of the occurrence of diseases
- Metaphylaxis i.e. for treating and preventing the recurrence of diseases
- Improving the development and acceleration of building of muscles

It is true that in recent years in almost all countries of the world, there is excessive use of antibiotics. Farmers feed farm animals with million kilograms of antibiotics as growth promoters.

This results in the rapid development of resistance to antibiotics not only from pathogenic organisms, but also to the change of endogenous microflora of the digestive system which is transferred from generation to generation for thousands of years.

The global scientific community is on alert. The era of antibiotics is ending. Of course due to them, to a great extent, the world's population in the 20th century quickly reached 7 billion inhabitants.

The victorious attack against bacteria is over.

Among the bacteria, resistant strains have already appeared that do not respond to any antibiotic.

Antibiotics are substances produced by yeast, fungi, algae and bacteria to protect them and to destroy their rivals in the struggle for nutrients. The mechanism of resistance to antibiotics has developed during the 3.5 billion years of existence and evolution of bacteria. Thus, antimicrobial resistance is a derivative of the natural environment of the planet.

This is the first direct demonstration that antibiotic resistance is a widespread natural phenomenon that existed before the modern use of antibiotics. The fact that the resistance genes are both ancient and widespread, means that there are no easy solutions to the problem of resistance and probably a ledger antibiotic will never be found or created.

The Universal Conference of the World Organisation for Animal Health held in 2013 in Paris, had as main theme the wise and responsible use of antibiotics. At the conference, consensus was reached on the need for an international cooperation and solidarity for the assurance of supervision of the imports, marketing, distribution and use of antibiotics.

In the decisions that were taken, it was agreed that, at a global level, a more restrictive legislation on good practice in production management, imports, registration, marketing, distribution and use of veterinary quality drugs should be taken and also to ban the use of certain antibiotics.

Other important conclusions of the Conference were:

- Antibiotics are not simple products and the sale as well as their use cannot be free. There is not a total optimum antibiotic delivery system to the farms.
- The optimum way for the delivery of antibiotics to farms and their use for the treatment of animals is via a veterinary network where specialists' veterinarians with special training `are working.
- The veterinary practice, as well as the medical and pharmaceutical ones, will be conducted in accordance with the laws which guarantee the ethics and exclude the use of self-interest for the prescribing and use of antibiotics.

This is one of the most important points in the practice of good administration as declared by the World Organisation for Animal Health (OIE) and provide a basis for the implementation of OIE programs. OIE fully supports the concept of "Unified health" that include the triangle animal - man - environment.

Over 60% of infectious diseases of animals and humans caused by the same pathogens, which requires that priority should be given to strengthen and improve the coordination of activities for the protection of animal and human health, taking into account the impact of environmental factors.

In this context, the World Organisation for Animal Health has proceeded in the following actions:

- The requirements for the rules of good management by the Veterinary Services have been improved for a better control of the registration, importation, distribution and use of antibiotics in farms.
- The information and monitoring system of the antibiotics used in animal husbandry have been improved.
- The harmonization of national monitoring and surveillance programs for antibiotic resistance of pathogenic and toxigenic microorganisms, especially salmonella, is in development, and the international coordination and improve of national programs is completed.

For antibiotic-resistant bacteria there are no borders. Mismanagement of antibiotics in one country may endanger many other. The members of the World Conference on antibiotics supported the strengthening of cooperation to help the countries which are still not using the OIE standards on antibiotics.

The growing lack of sensitivity for antibiotic, of the pathogens that cause dangerous human diseases (over 60% of these are common diseases in humans and animals) equalized from the chief doctor of Britain, Sally Davies, with a terrorist threat. Up to three thousand patients die each year in the UK due to the ineffectiveness of antibiotics because the pathogens of infectious diseases are resistant to them.

The development of new generation antibiotics deemed unprofitable worldwide. A typical example is that since 1987 not any new antibiotic has been developed.

ALTERNATIVE TO ANTIBIOTICS

There are actions that can be made which offer an alternative to antibiotics. These are:

- Ensuring animal welfare
- Vaccines
- Probiotics
- Prebiotics
- Herbal preparations - Phytomedication
- Essential oils
- Heavy metals
- Small interfering RNA (siRNA)
- Recombinant and medical hyperimmune sera
- Organic acids
- Bacteriophages
- Genetic products by bacteriophages
- Antibacterial products of animal origin
- Naturally antibacterial lytic enzymes
- Immunostimulants

ANTIMICROBIAL PEPTIDES OF ANIMAL ORIGIN

TThe antimicrobial peptides of animal origin are present in all organisms.

- The oldest of these are:
- Cathelicidin (snakes)
- Plastrin (frogs)
- Cecropin (insects)
- Bacteriocin (bacteria)

These peptides are characterized by their rapid onset of their action after the introduction and have a broad spectrum of activity, they are at the forefront of the fight against infections.

They kill bacteria destroying their membranes, while some peptides destroy the intracellular structures and have cytotoxic activity.

The American Chemist Society, based on a study of 600 species of frogs found that the skin of frogs may be a source of strong antibiotics. The scientists were able to identify more than one hundred compounds with antibacterial properties on the skin of different species of frogs. Thus the skin of frogs, who are on Earth for about 300 million years is a possible source of antibacterial agents.

ALTERNATIVE SUBSTANCES IN ANTIBIOTICS

Considered as drugs or biological products, or feed additives.

They must be produced in accordance with national and international standards, by firms which are licensed to produce them under the supervision of the authorized services.

They must comply with established standards for safety, quality and efficacy.

PERSPECTIVES

The integration of scientific research in the field of Nutritional Science, Health and the study of diseases resulting from the technological progress and the use of «omics*» – technologies in animal husbandry.

*** « Omics» – the common name of a number of biological disciplines of science: genomics, proteomics, metabolomics, etc.**

These technological developments will include new research methods, which will give scientists the not available before ability to identify the mechanisms by which it is possible to use alternative means to improve health, productivity and welfare of animals.

There is an urgent need for the development of new antimicrobials and of alternative means for the prevention and treatment of infectious diseases, to limit the application of antibiotics used now, but we must take into account the problem of resistance.

A cooperation between the scientific and government experts should be established, between the feed and pharmaceutical industry and the relevant regulatory authorities, to ensure the development of effective and safe alternatives.

Understanding the mechanism of the development of resistance to antibiotics will continue to be a major issue.

However, it is necessary to have the support of all parties concerned, corporates and public and governmental organizations, in the field of solving both the problem of the development of solutions with a reduced risk of microbial resistance, and the development of alternative approaches for improving the health and welfare of animals.

OIE list of antimicrobial agents of Veterinary importance (OIE list)

Antimicrobial agents (class, sub-class, substance)	Species	Specific comments	VCIA	VHIA	VIA
AMINOCOUMARIN Novobiocin	BOV, CAP, OVI, PIS	Novobiocin is used in the local treatment of mastitis and in septicaemias in fish			X
AMINOGLYCOSIDES		The wide range of applications and the nature of the diseases treated make aminoglycosides extremely important for veterinary medicine. Aminoglycosides are of importance in septicaemias; digestive, respiratory and urinary diseases. Gentamicin is indicated for Pseudomonas aeruginosa infections with few alternatives. Apramycin and Fortimycin are currently only used in animals. Few economic alternatives are available.	X		
AMINOCYCLITOL Spectinomycin	AVI, BOV, CAP, EQU, LEP, OVI, PIS, SUI				
Streptomycin	API, AVI, BOV, CAP, EQU, LEP, OVI, PIS, SUI				
Dihydrostreptomycin	AVI, BOV, CAP, EQU, LEP, OVI, SUI				
AMINOGLYCOSIDES +2 DEOXYSTREPTAMINE Kanamycin	AVI, BOV, EQU, PIS, SUI				
Neomycin	API, AVI, BOV, CAP, EQU, LEP, OVI, SUI				
Framycetin	BOV, CAP, OVI				
Paromomycin	AVI, BOV, CAP, OVI, LEP, SUI				
Apramycin	AVI, BOV, LEP, OVI, SUI				
Fortimycin	AVI, BOV, LEP, OVI, SUI				
Gentamicin	AVI, BOV, CAM, CAP, EQU, LEP-,OVI, SUI				
Tobramycin	EQU				
Amikacin	EQU				

AMPHENICOLS Florphenicol Thiamphenicol	AVI, BOV, CAP, EQU, LEP, OVI, PIS, SUI AVI, BOV, CAP, OVI, PIS, SUI	The wide range of applications and the nature of the diseases treated make phenicols extremely important for veterinary medicine. This class is of particular importance in treating some fish diseases, in which there are currently no or very few treatment alternatives. This class also represents a useful alternative in respiratory infections of cattle, swine and poultry. This class, in particular florfenicol, is used to treat pasteurellosis in cattle and pigs.	X		
ANSAMYCIN – RIFAMYCINS Rifampicin Rifaximin	EQU BOV, CAP, EQU, LEP, OVI, SUI	This antimicrobial class is authorised only in a few countries and with a very limited number of indications (mastitis) and few alternatives. Rifampicin is essential in the treatment of Rhodococcus equi infections in foals. However it is only available in a few countries, resulting in an overall classification of VHIA.		X	
ARSENICAL Roxarsone Nitarsone	AVI, SUI AVI, SUI	Arsenicals are used to control intestinal parasitic coccidiosis. (Eimeria spp.).			X
BICYCLOMYCIN Bicozamycin	AVI, BOV, PIS, SUI	Bicyclomycin is listed for digestive and respiratory diseases in cattle and septicaemias in fish.			X
CEPHALOSPORINS					
CEPHALOSPORINS FIRST GENERATION Cefacetrile Cefalexin Cefalotin Cefapyrin	BOV BOV, CAP, EQU, OVI, SUI EQU BOV	Cephalosporins are used in the treatment of septicemias, respiratory infections, and mastitis.		X	

Cefazolin Cefalonium	BOV, CAP, OVI BOV, CAP, OVI				
CEPHALOSPORINS SECOND GENERATION Cefuroxime	BOV				
CEPHALOSPORINS THIRD GENERATION Cefoperazone Ceftiofur Ceftriaxone	BOV, CAP, OVI AVI, BOV, CAP, EQU, LEP, OVI, SUI AVI, BOV, OVI, SUI	The wide range of applications and the nature of the diseases treated make cephalosporin third and fourth generation extremely important for veterinary medicine. Cephalosporins are used in the treatment of septicemias, respiratory infections, and mastitis. Alternatives are limited in efficacy through either inadequate spectrum or presence of antimicrobial resistance.	X		
CEPHALOSPORINS FOURTH GENERATION Cefquinome	BOV, CAP, EQU, LEP, OVI, SUI				
FUSIDIC ACID Fusidic acid	BOV, EQU	ACID Fusidic acid is used in the treatment of ophthalmic diseases in cattle and horses.			X
IONOPHORES Lasalocid Maduramycin Monensin Narasin Salinomycin Semduramicin	AVI, BOV, LEP, OVI AVI API, AVI, BOV, CAP AVI, BOV AVI, LEP, BOV, SUI AVI	Ionophores are essential for animal health because they are used to control intestinal parasitic coccidiosis (Eimeria spp.) where there are few or no alternatives available. Ionophores are critically important in poultry. This class is currently only used in animals		X	
LINCOSAMIDES Pirlimycin Lincomycin	BOV, SUI, AVI API, AVI, BOV, CAP, OVI, PIS, SUI	Lincosamides are essential in the treatment of Mycoplasmal pneumonia, infectious arthritis and hemorrhagic enteritis of pigs		X	
MACROLIDES (C refers to the chemical structure)		The wide range of applications and the			

MACROLIDES C14 Erythromycin Oleandomycin	API, AVI, BOV,CAP, EQU, LEP, OVI, PIS, SUI BOV	nature of the diseases treated make macrolides extremely important for veterinary medicine. Macrolides are used to treat Mycoplasma infections in pigs and poultry, haemorrhagic digestive disease in pigs (Lawsonia intracellularis) and liver abscesses (Fusobacterium necrophorum) in cattle, where they have very few alternatives. This class is also used for respiratory infections in cattle	X		
MACROLIDES C15 Gamithromycin Tulathromycin	BOV BOV, SUI				
MACROLIDES C16 Carbomycin Josamycin Kitasamycin Spiramycin Tilmicosin Tylosin Mirosamycin Terdecamycin Tildipirosin Tylvalosin	AVI AVI, PIS, SUI AVI, SUI, PIS AVI, BOV, CAP, EQU, LEP, OVI, PIS, SUI AVI, BOV, CAP, LEP, OVI, SUI API, AVI, BOV, CAP, LEP, OVI, SUI API, AVI, SUI, PIS AVI, SUI BOV, SUI AVI, SUI				
MACROLIDES C17 Sedecamycin	SUI				
ORTHOSOMYCINS Avilamycin	AVI, LEP	Avilamycin is used for enteric diseases of poultry and rabbit. This class is currently only used in animals			X
PENICILLINS					
NATURAL PENICILLINS (including esters and salts) Benethamine penicillin Benzylpenicillin	BOV AVI, BOV, CAM, CAP, EQU, LEP, OVI, SUI	Penethamate (hydroiodide) is currently only used in animals The wide range of applications and the nature of the diseases treated make penicillins extremely important for	X		

Penethamate (hydroiodide) Benzylpenicillin procaine / Benzathine penicillin	BOV BOV, CAM, CAP, EQU, OVI, SUI	veterinary medicine. This class is used in the treatment of septicaemias, respiratory and urinary tract infections. This class is very important in the treatment of many diseases in a broad range of animal species. Few economical alternatives are available.			
AMDINOPENICILLINS Mecillinam	BOV, SUI				
AMINOPENICILLINS Amoxicillin Ampicillin Hetacillin	AVI, BOV, CAP, EQU, OVI, PIS, SUI AVI, BOV, CAP, EQU, OVI, PIS, SUI BOV				
AMINOPENICILLIN + BETALACTAMASE INHIBITOR Amoxicillin + Clavulanic Acid Ampicillin + Sulbactam	AVI, BOV, CAP, EQU, OVI, SUI AVI, BOV, SUI				
CARBOXYPENICILLINS Ticarcillin Tobicillin	EQU PIS				
UREIDOPENICILLIN Aspoxicillin	BOV, SUI				
PHENOXYPENICILLINS Phenoxymethylpenicillin Phenethicillin	AVI, SUI EQU				
ANTISTAPHYLOCOCCAL PENICILLINS Cloxacillin Dicloxacillin Nafcillin Oxacillin	BOV, CAP, EQU, OVI, SUI BOV, CAP, OVI, AVI, SUI BOV, CAP, OVI BOV, CAP, EQU, OVI, AVI, SUI				

PHOSPHONIC ACID Fosfomycin	AVI, BOV, PIS, SUI	Fosfomycin is essential for the treatment of some fish infections with few alternatives however it is only available in a few countries, resulting in an overall classification of VHIA.		X	
PLEUROMUTILINS. Tiamulin Valnemulin	AVI, CAP, LEP, OVI, SUI AVI, SUI	The class of pleuromutilins is essential against respiratory infections in pigs and poultry. This class is also essential against swine dysentery (Brachyspira hyodysenteriae) however it is only available in a few countries, resulting in an overall classification of VHIA		X	
POLYPEPTIDES		Bacitracin is used in the treatment of necrotic enteritis in poultry. This class is used in the treatment of septicaemias, colibacillosis, salmonellosis, and urinary infections. Cyclic polypeptides are widely used against Gram negative enteric infections.		X	
Enramycin Gramicidin Bacitracin	AVI, SUI EQU AVI, BOV, LEP, SUI, OVI				
POLYPEPTIDES CYCLIC Colistin Polymixin	AVI, BOV, CAP, EQU, LEP, OVI, SUI BOV, CAP, EQU, LEP, OVI, AVI				
QUINOLONES		Quinolones of the 1st generations are used in the treatment of septicaemias and infections such as colibacillosis.		X	
QUINOLONES FIRST GENERATION Flumequin Miloxacin Nalidixic acid Oxolinic acid	AVI, BOV, CAP, EQU, LEP, OVI, PIS, SUI PIS BOV AVI, BOV, LEP, PIS, SUI, OVI				
QUINOLONES SECOND GENERATION (FLUOROQUINOLONES) Ciprofloxacin Danofloxacin	AVI, BOV, SUI	The wide range of applications and the nature of the diseases treated make fluoroquinolones extremely important for	X		

Difloxacin Enrofloxacin Marbofloxacin Norfloxacin Ofloxacin Orbifloxacin Sarafloxacin	AVI, BOV, CAP, LEP, OVI, SUI AVI, BOV, LEP, SUI AVI, BOV, CAP, EQU, LEP, OVI, PIS, SUI AVI, BOV, EQU, LEP, SUI AVI, BOV, CAP, LEP, OVI, SUI AVI, SUI BOV, SUI PIS	veterinary medicine. Fluoroquinolones are critically important in the treatment of septicaemias, respiratory and enteric diseases.			
QUINOXALINES Carbadox Olaquindox	SUI SUI	Quinoxalines (carbadox) is used for digestive disease of pigs (e.g. swine dysentery). This class is currently only used in animals.			X
SULFONAMIDES Sulfachlorpyridazine Sulfadiazine Sulfadimethoxine Sulfadimidine (Sulfamethazine, Sulfadimerazin) Sulfadoxine Sulfafurazole Sulfaguanidine Sulfamerazine	AVI, BOV, SUI AVI, BOV, CAP, OVI, SUI AVI, BOV, CAP, EQU, LEP, OVI, PIS, SUI AVI, BOV, CAP, EQU, LEP, OVI, SUI BOV, EQU, OVI, SUI BOV, PIS AVI, CAP, OVI	The wide range of applications and the nature of the diseases treated make sulfonamides extremely important for veterinary medicine. These classes alone or in combination are critically important in the treatment of a wide range of diseases (bacterial, coccidial and protozoal infections) in a wide range of animal species.	X		

Sulfadimethoxazole Sulfamethoxine Sulfamonomethoxine Sulfanilamide Sulfapyridine Phthalylsulfathiazole Sulfaquinoxaline	AVI, BOV, CAP, EQU, LEP, OVI, PIS, SUI AVI, BOV, SUI AVI, PIS, SUI AVI, PIS, SUI AVI, BOV, CAP, OVI BOV, SUI SUI AVI, BOV, CAP, LEP, OVI				
SULFONAMIDES+ DIAMINOPYRIM-IDINES Sulfame-thoxypyridazine Ormetoprim+ Sul-fadimethoxine Trimethoprim+ Sul-fonamide	AVI, BOV, EQU, SUI PIS AVI, BOV, CAP, EQU, LEP, OVI, PIS, SUI				
DIAMINOPYRIMI-DINES Baquiloprim Trimethoprim Ormetoprim	BOV, SUI AVI, BOV, CAP, EQU, LEP, OVI, SUI AVI				
STREPTOGRAMINS Virginiamycin	AVI, BOV, OVI, SUI	Virginiamycin is an important antimicrobial in the prevention of necrotic enteritis (Clostridium perfringens)			X
TETRACYCLINES Chlortetracycline Doxycycline	AVI, BOV, CAP, EQU, LEP, OVI, SUI AVI, BOV, CAM, CAP,	The wide range of applications and the nature of the diseases treated make tetracyclines extremely important for veterinary medicine This class is critically important in the	X		

Oxytetracycline Tetracycline	EQU, LEP, OVI, PIS, SUI API, AVI, BOV, CAM, CAP, EQU, LEP, OVI, PIS, SUI API, AVI, BOV, CAM, CAP, EQU, LEP, OVI, PIS, SUI	treatment of many bacterial and chlamydial diseases in a wide range of animal species. This class is also critically important in the treatment of animals against heartwater (Ehrlichia ruminantium) and anaplasmosis (Anaplasma marginale) due to the lack of antimicrobial alternatives.			
THIOSTREPTON Nosiheptide	AVI, SUI	This class is currently used in the treatment of some dermatological conditions.			X

Abbreviations:

Animal species in which these antimicrobial agents are used are abbreviated as follows:

AVI: avian

EQU: Equine

API: bee

LEP: Rabbit

BOV: bovine

OVI: Ovine

CAP: caprine

PIS: Fish

CAM: camel

SUI: Swine

VCIA: Veterinary Critically Important Antimicrobial Agents

VHIA: Veterinary Highly Important Antimicrobial Agents

VIA: Veterinary Important Antimicrobial Agents

Emerging Diseases: a potential threat for the pig industry

Charalambos Billinis,

Dean, School of Health Sciences–Professor, Department of Microbiology and Parasitology, Faculty of Veterinary Science, University of Thessaly

The term emerging diseases includes infectious diseases that have recently been described or developed or diseases which, while were already known, recently increased their incidence or their expansion into new geographic areas or infect new hosts or employ new carriers.The concept of "emerging diseases" developed by scientists who were trying to document and explain the sudden increase in the number of new and important diseases during the past two decades.

The procedures and factors that led to the rise of emerging diseases are:

1. Changes concerning the pathogens themselves or their range of hosts (breaking the barrier of the kind),
2. Changes of the ecosystem due to natural or anthropogenic causes along with climatic and geographical influences to pathogens and their carriers,
3. Intense movements of the human population and their increased contact with animals or their products,
4. Increased movement of animals and animal products,
5. The improvement of diagnostic and epidemiological techniques resulting in the detection of existing or emerging pathogens.

Among emerging pig diseases, a lot of them have already a major impact on Greek pig production, while others may affect it in the future.The main emerging diseases which had an increased incidence in previous years in Greece, as well as those which may occur in the near future, are discussed below. These diseases are Swine Encephalomyocarditis, Porcine Reproductive and Respiratory Syndrome, Swine Influenza and African Swine Fever.

Encephalomyocarditis was first reported, as a clinical disease in pigs, in Panama in 1958 and Florida in 1960.The disease described was characterized by sudden deaths in young animals without prodromal symptoms. In the following years cases were reported in Australia, Belgium, North America, Brazil, Greece, Italy, Cuba, Cyprus, New Zealand and several Asian countries. Apart from the sudden deaths in young animals, it was found that the virus of encephalomyocarditis was the causative pathogen of reproductive problems reported in America, Australia, Belgium, Canada and Cuba. The disease first appeared in Greece during the period 1986-1989 in the cardiac form. The occurrence of these outbreaks coincided with the presence of large numbers of rodents in the areas around the farms. In the following years sporadic cases of the cardiac form of the disease continued to appear in herds of Northern Greece. Dead animals showed the typical lesions of the disease in the heart. Cause of the disease is the virus of encephalomyocarditis belonging to the Picornaviridae family. The disease is often characterized by acute onset of sudden deaths due to heart failure. Infected pigs die suddenly or are found dead without premonitory symptoms.In some of the infected animals it may be observed lethargy, anorexia, tremor, paralysis, vomiting and dyspnea. Mortality is high up to 100% for nursing piglets and then is restricted at the age of weaning. In pregnant sows may occur reproductive problems, which are characterized by reduced fertility rate, fetal absorption abortion, birth of stillborn and mummified piglets and deaths in newborns. The most characteristic macroscopic lesions found in the heart. The heart is flabby, discolored with piebald areas, most commonly found in the myocardium of the right ventricle near the pulmonary artery, the interventricular septum and the papillary muscles. The lesions may be located at any depth of the myocardium, and sometimes exhibit deposition of calcium salts in their center. The right ventricle and the right atrium of the heart appear enlarged. Rodents, especially rats, are described as a reservoir of the virus and are considered responsible for the observed outbreaks. The virus is excreted via their faeces and urine, and is found in high titers in their tissues. Therefore, the exposure of pigs to infected with the virus feed or water, as well as in infected rodent corpses plays an important role in disease transmission. The infected pigs shed the virus for a short period of time and the virus is transmitted from pig to pig by contact. Relating to Public Health: Encephalomyocarditis virus has been isolated from cerebrospinal fluid, blood, faeces and ear rinse of people, especially children, with aseptic meningitis, acute idiopathic polyneuritis (Guillain-Barré syndrome), encephalomyelitis, fever of unknown cause and a disease with poliomyelitis symptoms. Usually, the infection in humans is rather common, but typically asymptomatic or undiagnosed. The detection of the virus is achieved by inoculating appropriately prepared suspension from pathological material in cell cultures. Detection of the virus is also achieved with the inoculation of pathological material in white muscles. Also the method of the polymerase chain reaction (PCR) is applied for the detection of encephalomyocarditis virus. Detection of antibodies to EMC virus is primarily performed with serum neutralization test. Differential diagnosis of the cardiac form of the disease should be carried out for diseases that occur with sudden death as the edema disease in weaned piglets, lack of selenium and vitamin E, foot and mouth disease and swine fever. For the reproductive form of the disease differential diagnosis should be done from diseases with similar symptoms, such as PRRS, Aujeszky's disease and Parvovirus. There is no treatment for the infection from encephalomyocarditisvirus. However, avoiding or reducing animal stress may reduce mortality. To prevent the disease, it is recommended to apply biosecurity measures, especially concerning hygiene with frequent disinfection and rodent control. Commonly disinfectants based iodine or mercury chloride are used.

Porcine Reproductive and Respiratory Syndrome, (PRRS) is a viral etiology disease. The virus belongs to the genus Arterivirus, of the Arteriviridae family. The virus causes death in newborn piglets, respiratory symptoms with growth retardation in growing and finishing pigs and reproductive problems in pregnant sows. The disease first appeared in 1987 in the USA. In Europe, the disease first appeared in Germany in 1990 and then spread to all countries. In Greece the disease first appeared in 1993. In the following years strains of the virus of different virulence appeared. The severity of symptoms of the disease depends on the virulence of the virus strain, and the health status of the infected farm. The virus strains differ in both antigenically and virulence. More specifically, there are two groups of strains. The first group includes strains of the virus that have been isolated in the USA and Canada (Americans strains) and the second strains isolated in Europe (European strains). Infection of pigs primarily occurs from the respiratory tract and rarely can occur through the genital tract. Target of the virus are mainly the alveolar lung macrophages, the macrophages in various tissues and monocytes. In chronic virus infection the virus is detected in the lymph nodes and the tonsils. The viral extensive proliferation leads to the destruction of the alveolar macrophages, resulting in the reduction of the defense mechanism of the animals. This fact leads to an increase of their susceptibility to other viral or bacterial infections. Damages of the endothelium of capillaries and increased intravascular coagulation are observed, resulting in cyanosis of the ears, tail and limbs. In **breeding animals** initially general symptoms are observed such as depression, lethargy, shortness of breath and temperature rise. In a small percentage of sows (1-2%) vascular disorders may occur (hyperemia or cyanosis) located in the skin, vulva, breast and ears (blue ear). In sows an increase in the percentage of returns to oestrus, abortions usually the last third of gestation, and especially premature births between the 107th and 112th day of pregnancy is noted. Often the birth of stillborn, mummified and weak piglets also noted. The boars during the acute syndrome exhibit anorexia, lethargy, respiratory symptoms (transient coughing and sneezing), reduced libido, mild fever and edema of the eyelids, ears and testicles. But in most cases exhibit a subclinical infection without apparent externally clinical symptoms, dispersing the virus via the semen. Also, the PRRS virus have a negative effect on macroscopic and microscopic characteristics of sperm, causing a decrease in semen volume, decreased of mobility and vitality of sperm and increase of the numbers of spermatozoa with morphological abnormalities leading eventually to a decrease in fertility. **In newborn piglets** the mortality rate can reach 40% and it is noted not only to the piglets born underweight, but also to those that are born with normal vigor. Mortality is higher during the first week after birth, but may continue until weaning. Piglets born weak or with dissipation of the hind limbs (splay-leg), they have difficulty to nurse and therefore consume a small amount of colostrum. This results in both the occurrence of hypoglycemia, and also increased susceptibility to secondary infections. These pathological conditions exacerbated by the appearance in the affected sows postpartum hypogalaxia / dysgalaxiasyndrome. In older piglets' dyspnea, depression, inability to support the limbs and bruising which are characteristic in the eyelids and conjunctiva,are noted. **In growing - finishing pigs'** respiratory symptoms are observed. Infected animals have cough, abdominal breathing, fever, depression, anorexia and growth retardation.Affected pigs often have overgrowth of hair and varying degrees of reduction in the average daily weight gain and feed conversion ratio as a result a disparity to growth between the same age animals is noted. PRRS virus enters a farm with the importation of infected replacement breeding animals (boars, gilts).The virus can also be transported airborne over short distances between neighboring farms. Sows can also become contaminated during natural service by an infected boar and / or by infected semen during artificial insemination. Mechanical vectors of the virus can be various insects (flies, mosquitoes), the farm's staff (boots, clothing) and various visitors (eg veterinarians, visitors, etc.), that are not taking the right biosecurity measures. The clinical diagnosis is based on the appearance at the same time in a farm, increasing proportion of deaths in newborn piglets, together with respiratory symptoms in growing / finishing pigs, as well as, the appearance of reproductive problems in pregnant sows.The differential diagnosis should include Aujeszky's disease, Parvovirus, Transmissible Gastroenteritis, Classical and African Swine Fever, Leptospirosis and Erysipelas.Definitive diagnosis is done only by a laboratory. The laboratory diagnosis is done primarily by detection of antibodies as well as the isolation and identification of the virus.The detection of viral nucleic acid by the technique of polymerase chain reaction is the fastest and most accurate method of diagnosis. Prevention measures for PRRS include both sanitary measures and vaccinations. On farms that are free from the disease checks are performed both on animals entering the unit and to the semen used for artificial insemination. On farms that are considered infected additional measures to improve animal welfare should be taken. To prevent the disease vaccines are also used. The vaccines used to immunize pigs contain either inactivated virus strains or live modified minimum virulence strains.

Swine influenza is a disease of viral etiology of particular importance for public health. The disease can occur in a farm with epizootic and enzootic form.In the epizootic form the virus spreads rapidly in all groups of pigs in the farm displaying classic respiratory symptoms. Conversely, in enzootic form the impact of influenza is not evident and the clinical picture is not the classic of influenza. Morbidity is very high and can reach 100%, but mortality is very low. In recent years' influenza has become particularly important for both pigs and public health because of the potential for the appearance new types of viruses. According to the classical theory for the creation of a new influenza virus capable of causing a pandemic, the presence of an intermediate host is needed, which will be the "mixing vessel" through which a new influenza virus with genes from avian viruses could be transmitted in humans. Most experts agree that this role could be played by the pig. The above theory was confirmed in 2009 with the emergence of the 'novel influenza' strain H_1N_1. This new virus was derived from recombinant viruses of pig, avian and human flu. According to the World Health Organization, millions of people worldwide infected with the virus, but the mortality rate was extremely low. It turned out that although the new H1N1 virus met the formal criteria for declaring it pandemic, it is not multiplied in high rates in the human respiratory system. The virus of swine influenza belongs to the genus Influenza virus A, of the *Orthomyxoviridae* family. Influenza A viruses are further characterized into subtypes based on two surface glycoproteins that have hemagglutinin and neuraminidase. In recent years, influenza viruses that infect pigs, contain sections of genetic material of avian and human influenza viruses. Infection of pigs takes place from the respiratory tract by inhalation of microdroplets. The swine influenza virus enters a farm with the introduction of an infected animal.When a farm is infected for the first time, all the animals are getting ill (100% mortality), but most recover 3-7 days in the absence of secondary complications. Where there are no secondary complications the mortality rate is very low, ranging from 1-2%. On farms where the virus is endemic, infection is subclinical.In these cases, typical symptoms of the disease occur in 25-30% of animals. Influenza is one of the major causes of respiratory syndrome in growing / fattening pigs worldwide. Approximately 25-33% of pigs aged 6-7 months and 45% of breeding pigs have antibodies against the virus. The laboratory diagnosis includes the isolation and identification of the virus, the detection of viral nucleic acid and the detection of antibodies against the virus. As for the differential diagnosis, it should be distinguished from all the diseases involved in the etiology of the respiratory syndrome as the Porcine Respiratory and Reproductive Syndrome (PRRS), Aujesky disease, Circovirus type 2, Pleuropneumonia, Pasteurellosis and Enzootic Pneumonia. To prevent swine influenza, strict biosecurity measures should be applied to prevent the introduction and spreading of the virus within the farm. Reducing the density of animals, early weaning of piglets, total application of all in - all out system, in combination with good hygiene are the measures that can be taken to reduce financial losses in livestock farming.Vaccines are also used for the prevention of the disease. The presence of secondary bacterial complications worsens the clinical picture of influenza.

African Swine Fever is a human orientated and very contagious disease of viral etiology, with clinical symptoms similar to those of classical swine fever. African Swine Fever belongs to the list A of the International Office for Epizootics and is a notifiable disease in Europe. The appearance of the disease causes great economic losses due both to the high mortality rates, and secondly to the restriction of animals and products movement and the compulsory slaughter of infected pigs. African Swine Fever was first described in Kenya in 1921. The disease remained localized in Africa until 1957, the year in which the disease began spreading in Europe. The virus was detected for the first time in Eastern

Europe in 2007 and since then has expanded to Central Europe. The African Swine Fever belongs to the Asfivirus genus of the Asfarviridae family. He is the only DNA virus transmitted by arthropods. Soft ticks of the genus Ornithodoros are the biological vectors of the virus, in which is multiplied and transmitted from a tick development stage to another and also with transovarial transmission. The virus strains differ in their virulence, but belong to the same serotype. The virus initially installed and multiplies in the tonsils. Viremia and spreading of the virus throughout the body follows. Target of the virus are the endothelial cells of the blood vessels, the blood monocytes and the macrophages of various organs such as the liver, spleen and kidneys. Additionally, a blood clotting disorder is noted. The destruction of the endothelial cells of the blood vessels results in the creation of lesions in their walls, which leads to edema and hemorrhage. The virus spreads with all the secretions and excretions of diseased animals while substantial amounts of virus are found in the blood and tissues, including the muscle tissue. In the blood of animals, the virus continues to circulate and after their recovery. The virus is sufficiently robust and has a remarkable long-term preservation in meat and meat products, which contribute to the dispersing in remote areas. Specifically, the virus survives for 3-6 months' time in uncooked pork products. Also the virus survives at extremes pH values(3.9-13.4) while it remains infectious in contaminated animal faeces at room temperature for about 10 days. Virus inactivation requires heating at 56°C for 70 minutes or at 60°C for 20 minutes. The diagnosis of African Swine Fever can be done only with laboratory tests. With clinical examination somebody can only suspect the disease and only for the acute form, which will be based on the symptoms observed similar to classical swine fever, which includes attack of pigs of any age who experience extensive hemorrhages in the skin and various internal organs and high mortality rates. Differential diagnosis should also be made from classical swine fever, PRRS, encephalomyocarditis virus, erysipelas, salmonellosis, Aujeszky's disease, pasteurellosis, and poisoning by anticoagulants. For laboratory diagnosis the mainly methods used are designed to detect and identify the virus. Suitable tissues for the isolation and identification of the virus are the lymph nodes, spleen, tonsils and kidneys. Also blood samples with anticoagulants should be taken in the early stages of the disease. Serological tests are performed in cases of epidemiological investigation of the disease. Antibodies are developed in the third week after infection. As already mentioned African Swine Fever belongs to the list A of the International Office for Epizootics and is a notifiable disease. Until now the prevention of the disease is based solely on hygiene measures. Special attention should be given, when implementing sanitary measures, to the fact that pigs survived the infection remain carriers of the virus throughout their lives and that boars remain asymptomatic carriers of the virus, thereby helping to maintain the disease in an area. In case of African Swine Fever occurrence, in areas free of the disease, eradication measures are implemented by the method of stamping out the infected farm.

DNA in the service of selection and improvement of livestock. The development and application of genomics as a new tool for improvement

Zissis Mamuris,
Professor of Genetics, Department of Biochemistry and Biotechnology,
Vice Rector of Research - University of Thessaly

Introduction

Over the last 50 years, we have experienced an unprecedented increase in the human population. Based on current projections, world population will reach 9 billion in 2030. To meet the growing need for food using fewer resources is one of the greatest challenges that modern agriculture faces. Recent estimates by the Food and Agriculture Organization of the United Nations show that, in order to meet the growing demand, food production must be doubled in the next 50 years. In other words, agriculture will have to produce more food than in the last 10,000 years altogether. When the year 2000 is used as a basis, predictions show an increase in global meat consumption by 68% and milk by 57% by 2030. The greatest demand for food based on animal proteins with the potential impact of climate change and water shortage, nutrients and energy will lead to big gaps in productivity. It is therefore vital that systematic application of technical and scientific methods to improve the food, nutrition, genetics, breeding, control of animal health, and the general improvement of livestock is performed in order to meet the upcoming productivity gaps. The greatest gains will come from innovations that accelerate agricultural productivity while reducing costs and reducing environmental impact.

The traditional breeding methods are successful, but limited

For centuries, farmers have very effectively manipulated the genomes of productive species, based on the fact that there are natural variations within a species, in a race, and in a population. Traditional breeding and improvement has happened due to the lack of knowledge of the molecular composition of genes controlling quantitative traits of animals. Breeders have improved productive traits in their herds, choosing the best individuals as ancestors for future generations. These improved "breeding values” were achieved by combining the phenotypic recording of individual performance with pedigree information. In Holstein dairy cattle, milk production continues to increase by 110 kg per animal per year. In pig production, the pounds of food required to produce one kilogram of pork, a parameter known as the feed conversion is estimated to have decreased by 50% between 1960 and 2005. Although these results are powerful examples of what can be achieved through traditional breeding methods, the effectiveness of these traditional methods is reduced when the traits are difficult to measure, have low heritability, or cannot be measured quickly, inexpensively and correctly on a large number of animals. Such difficulties in measuring and recording features are often extremely important because they include fertility, longevity, feed efficiency and disease resistance. The selection of these features must therefore be achieved through genomics.

The high expectations of Genomics

During the last 2 decades, the rapid development of genomics has opened new ways for the examination of the scientific basis of livestock biology and reproduction and has led to new production methods to achieve steady growth of feed yields and long-term improvements in efficiency of animal production. A new era, the “genomics era”, promises to enable an objective prediction of the effects that are based on direct access to the complete sequence of the DNA of many individuals, and therefore a renewed and more objective view of the genetic value of animals that is not limited to just a few features of production. One of the factors that triggered the development of this genomic era was the international program to decode the human genome. The goal of this project was to produce the first (de novo) complete DNA sequence of a human being. Along with this, came the development and application of new genomic tools, especially improved technologies of sequencing of DNA and the increased availability of high-performance platforms for the analysis of genotypes. The value for the sequencing of a single nucleotide of DNA has been reduced by 100 million times since 1990. Technological innovations that have led to this cost reduction have also facilitated the sequencing of entire genomes of many species.

Genomics: The passage of the Science of Animal Production in a new dimension

From a scientific point of view, the acceleration of the analysis of genomes on a wide scale will have a significant impact. It will give new information to the understanding of the basic structure and function of the livestock's genomes and it will further explain the control of complex traits. With the production of whole genome sequences for the major animal species at very low costs, a comparison of sequences from different individuals of different races to a reference sequence, resulted in the discovery of an almost inexhaustible source of genetic markers, especially polymorphisms in the form of single nucleotide polymorphism (SNP). Thus, the scientific community has gained access to millions of SNPs, but also free accessible databases (http://www.ncbi.nlm.nih.gov/projects/SNP). These databases contain information today for over 86 organisms and a total of over 50 million SNPs. Another important technological breakthrough was the development and continuous improvement of the technology of DNA arrays, allowing inexpensive analysis of SNPs in a given sample. The success of these DNA arrays is that they show a strong parallel processing ability and a remarkable ability to automate. Although first used for gene expression studies, these DNA arrays have proven very useful for the development of whole genome SNP panels for many species, including many productive species. With DNA-arrays, hundreds of thousands of SNP can be tested in parallel, allowing scientists to perform genome association studies, which would be impossible with other techniques or markers. In recent years, several studies have been published that demonstrate their effectiveness (e.g., BovineSNP50, OvineSNP50, EquineSNP50, PorcineSNP60).

Genomics: a paradigm shift in animal breeding

The greatest evolution is accomplished in the application of genomics in the design and implementation of breeding programs and promises profits throughout the value chain. For farmers and other members of the livestock industry, genomics is expected to increase the efficiency and productivity of livestock and for consumers and the manufacturing sector, is expected to enhance the safety and quality of animal products. The new knowledge acquired on the development, nutrition, health, and animal welfare should allow a better understanding of the molecular mechanisms of the traits of commercial interest. Therefore, genomics, tapping into new sources of genetic polymorphisms, creates further opportunities to improve the selection accuracy, while reducing the costs and time between generations.

Selection principle via Genomics

Selection via genomics was first described by Meuwissen et al. (2001) and is based on the fundamental principle that the information of a large number of markers could be used for the estimation of breeding value without precise knowledge of the location on the genome of these specific genes that control those characteristics. With tens of thousands of SNPs, well selected to be representative of the entire genome, it is expected that there will always be a SNP in the immediate vicinity of a specific gene or part of the DNA of interest and that the existing linkage disequilibrium between one (or more) SNPs and a gene allele will be significant and may then be used to explain a significant fraction of the variation of the desired characteristic. The first step in the selection process through genomics is, therefore, access to a large group of animals, or in a reference population with specific phenotypes for the targeted characteristic (s). This population should also be genotyped using either a series of SNPs across the genome, either already known SNPs in cases where these have been designated. Then, the data obtained will serve as a reference for the development of a statistical interaction estimation model of each SNP with the targeted characteristic (s). The result is a predictive equation for calculating a genomic estimated breeding value (GEBV). After a validation step, the genomic breeding value of new animals can be estimated using the prediction equation, based on the genotypes of the SNP array and the absence of any precise information about the phenotype of these animals **(Figure 1 and Table 1)**. The accuracy of the GEBV depends on the size of the population and the heritability of the targeted characteristic.

Table 1. *Example of a simplified calculation of the genomic breeding value, with 4 SNPs and estimated effects*

Ζώο	SNP1		SNP2		SNP3		SNP4		Γονιδιωματική Αξία Αναπαραγωγής
	Γενότυπος	Αξία	Γενότυπος	Αξία	Γενότυπος	Αξία	Γενότυπος	Αξία	
1	AA	8	BB	–4	AA	2	AA	–6	0
2	AA	8	AA	4	BB	–2	AB	0	10
3	AB	0	AB	0	AB	0	BB	6	6
4	AB	0	AB	0	AB	0	AA	–6	–6
5	BB	–8	AA	4	AA	2	AA	–6	–8
6	BB	–8	BB	–4	BB	–2	AB	0	-14

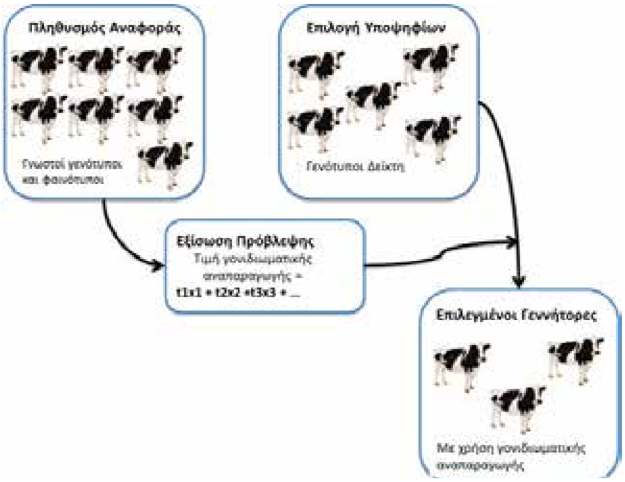


Figure 1. *A reference animal population is evaluated and graded for key production traits and genotypes using SNPs. The genotypes are represented by the variable X, with values 0, 1, 2 (homozygous, heterozygous or homozygous alternative). A predictive equation is generated by combining all genotypic markers with their results to calculate a genomic estimated breeding value for each animal. This prediction equation can be applied even in a group of animals which have not been phenotyped, breeding values can be evaluated, and the best animals can be selected for playback. Adapted from Goddard and Hayes (2009).*

The Application of Genomic Selection

The Genomic selection is based on existing breeding programs in which collecting genealogical information combined with phenotypic data is already a routine. It provides a new level of information that can be incorporated into the decision-making process for identifying and selecting the most productive animals. The main advantages of genomic selection is that it can be implemented very early in the life of the animal, is not limited to a particular sex, and may be extended to any characteristics which are recorded in a reference population. It provides, especially for hard to improve traits, a better selection accuracy, while reducing the time between generations, thus increasing the intensity of selection. Moreover, it is not limited to particular groups. Since 2006, Schaeffer (2006) showed that using genomic selection, genetic gain per year could double in dairy cattle, with the potential to reduce costs for the supply of bulls by more than 90%. Instead of cattle passing through a long and costly progeny testing by recording the phenotypic information for a large number of daughters, the exact GEBV data could be calculated through a cost-effective genomic study of the most suitable genotypes. Obvious benefits observed in dairy cattle can also be transferred to other species. The wider use of the genomics approach, or even the genomic selection, promises to be one of the next major advances in breeding programs for all animal species. As efficient genomics tools for animals, plants and fish continue to be developed, the respective breeding industries will be able to take decisions on selection earlier, to improve the characteristics that are difficult to treat with traditional methods, and provide customers with high-quality, safer food, while reducing the impact of farming on the environment (environmental footprint) and ensuring long-term sustainability products and livestock. The applications of genomics approach on the field, extend far beyond reproduction, because genomics tools can also provide accurate information on animal identification, validation of paternity (parentage) and traceability of food and animal breeds. Genomics can also be applied to the flock management process to optimize the mating and to reduce inbreeding.

The Next Wave of discoveries and new approaches

Arrays with higher density SNPs with several hundred thousand SNP have been developed for different species. In cattle, the success of genomic selection is extended by combining various breeds in order to increase the size of the reference population and generate ratings between tribes. This approach will prove very beneficial for breeds with a limited number of individuals or phenotypic records, or for species for which the reproduction between the races is an effective tool in the improvement process. As the cost of sequencing continues to be reduced and the access to the sequencing of the entire genome for specific individual is accessible, one of the next steps would be to include the sequencing data of the whole genome in routine genetic evaluations. According to a simulation presented by Meuwissen and Goddard (2010), a 40% gain in the accuracy of prediction of genetic values could be achieved by using the full sequencing instead of only the data of data from 30,000 SNPs arrays. Furthermore, using the sequencing data of the whole genome, the prediction of the genetic value remained accurate even when the reference and evaluation data were 10 generations apart, since the accuracy observed was similar to that for data from the same generation.

Opportunities for developing countries

In developed countries, phenotypes and lineages have been recorded for certain species, such as cattle, for more than 100 years. Progeny control is applied for 50 years. The implementation of improvement programs in developing countries is often limited by the absence of phenotype recording programs for various animal breeds and the lack of evaluation and national testing programs for assessing the genetic value of sires. The genomics approach should help identify critical populations for the maintenance of certain local breeds that are well adapted and could be used further to reproduce valuable animals through a combination of selection and breeding. Of course, as with genomics, we can manage only that we can measure and the collection of a minimum number of phenotypes will remain one of the crucial and difficult steps for the further development of genomic selection in developing countries.

Conclusions and Prospects for the Future

The ability to explore the genome, the trascriptome the epigenome and metagenome of any species with high efficiency sequencing methods opens up a new world of possibilities. Further reduction of sequencing costs will continue to lead to wider acceptance of new approaches and their application for the benefit of research on livestock and consumers. All cost-effective species, subspecies, and their pathogens will undoubtedly be sequenced in the near future. Thousands of related genomes will also be sequenced to test the genetic diversity, within and between genetic groups of stocks, providing important information for applying selection genomics programs in developed countries. The Genomic selection will surpass the conventional methods and specific genotypes that are detected by high performance genotyping systems, can be directly related to economic values. Breeding programs will be guided mainly by genomics data because of the higher cost and much higher performance. New expertise in the field of animal pharmacogenomics will help increase vaccines and the specificity of the drug while nutri-genomics will help create diets designed based on the genomic profile. As genomics will continue to provide extremely valuable biological information, the key to the further success of genomic selection and genomic approach will be to collect the most suitable phenotypes to identify the alleles that determine them and the precise mechanisms by which these are produced, and to combine these alleles in breeding lines in as few generations as possible. We are entering a truly exciting time powered by genomics.

Review

- There is a significant difference between demand, based on population growth, and the current state of the livestock performance. This is the entry point of genomics to livestock improvement.
- Although the traditional breeding methods have been proven effective in the selection of animals with easy measurement of productive characteristics, such methods have substantially reached their limits and characteristics that are more difficult to measure (and often the most important), are not selected efficiently by using traditional methods

- The race of competition for sequencing the first human genome, and then the struggle to make sequencing affordable for dozens, if not hundreds of thousands, additional human genomes has led to an unprecedented (100 million times) price reduction of sequencing DNA from 1990. Sequencing of animal genomes has benefited from this.
- Sequencing the genome of economically important species of livestock has resulted in the discovery of millions of single nucleotide polymorphisms (SNP). These single nucleotide polymorphisms have been developed parallel to DNA microarrays, allowing massive genome association studies to identify the genotype-phenotype correlations for both simple and, more importantly, for complex traits.
- Guided by a growing reduction of the cost of measuring genetic diversity, we are entering a new era in which the information from these studies on genome association level should be effectively used in routine tests using genomic selection. Selection through genomics analysis promises more promising results because it does not have the requirement of a priori knowledge for the position of alleles or molecular markers and the requirement that the selection by molecular marker should be implemented within families.

Sows Heat Stress

Dimitrios Kantas,

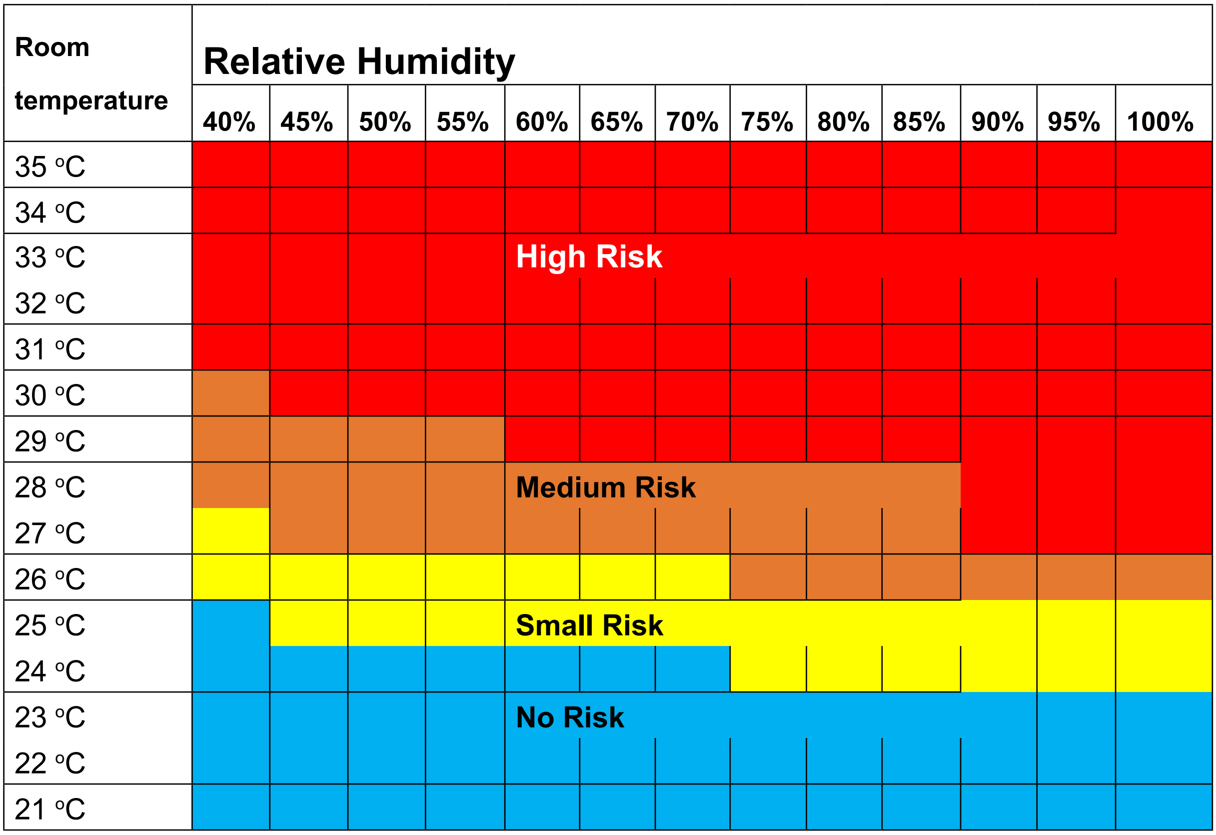
Professor, Department of Animal Production, School of Agricultural Technology, TEI of Thessaly

Pigs adapt relatively easily to environmental changes, which is very important for their survival. But for sows, this adaptation has a cost concerning productivity and longevity. Most animals' species can expel heat to the environment with perspiration and panting which are the two most important tools for maintaining body temperature. However, pigs do not sweat and have relatively small lungs. Because of these physiological constraints and the deposition of subcutaneous fat, they are susceptible to heat stress. In the U.S., the annual reduction in productivity is directly linked to the increased temperatures in July and August. However, production data suggest that the productivity loss extends from June to October for growing and finishing pigs and from July to November for sows' units. The net result? For about 40 percent of the time, the productivity of the plant is at risk. Additionally, today's modern genotypes of pigs produce significantly more heat than their ancestors.

A review (Brown-Brandl et al, 2003) of heat and moisture production from pigs suggested that new genetic lines produce almost 20% more heat than their counterparts in early 1980. This trend is likely to be continued in the coming years since this review was conducted and heat production could be increased by up to 10% extra.

When sows use natural coping - resistance mechanisms, for thermoregulation, they must allocate resources away from other body functions.The results may be damaging to sows' body condition; fertility; milk production and/or piglet survival and growth performance. The most common impact of heat stress is often decreased feed intake and increased breathing. The reduction in feed intake decreases endogenous heat production. Continuous heat stress increases excessively water consumption (increasing electrolyte loss) and accumulates acids, produced in the body and causing loss of acid-base balance. This may eventually result in diarrhea or death in severe cases. A recent publication by Pearce et al. (2013) examined what happened to the intestinal structure when pigs were exposed to heat stress. The research showed that exposure to 35°C for 24 hours significantly damaged the intestinal defense function and also increased plasma endotoxin levels. The authors explained that when pigs are exposed to heat stress (even for as little as two to six hours) their intestinal

defense systems are significantly compromised and this provides opportunity for infection as pathogenic bacteria can invade the body more easily. Therefore, heat stress can create secondary infection if sanitary conditions are poor.
As temperatures exceed 24°C, depending on humidity, sows can begin to experience the negative effects of heat stress (stress), mentioned above. Feed consumption is reduced by about 0.5 kg per day when the temperature rises to 25°C. Note that sows wellness zone is between 15-19°C. The influence of temperature in conjunction with humidity is shown in Scheme 1.



Scheme 1. *Temperature and moisture influence on thermal stress.*

Thermal stress can also affect boars, resulting in reduction of libido, low sperm count, abnormal sperm and following decreased litter size.
With the rise of temperature, sows increase their breathing rate in an attempt to expel heat. The shortness of breath is an obvious sign of heat stress, and causes sows to spend extra energy. Practically one sow has 15-20 breaths per minute. If exceeded 40 it is apparent that suffers from heat stress. ‘Other symptoms are: the sprawl on the floor or on cold surfaces, lower physical activity, search

for water or playing with the drinker and reduced feed intake.

The regulation of environmental conditions on site, can help in addressing the problem. Heat stress can be minimized by adjusting the temperature in the installation. Strategies for sufficient air circulation and cooling include: ventilation, air conditioning and refrigeration units, fresh air inlets and water spraying systems. With any of these systems, the temperature in the sows unit must be kept between 15-21°C.

The quantity of the air is an important factor for reducing thermal stress. General recommendations are shown in Table 1 (Data adapted from US). Note that these are averages values and in some areas they can be doubled, especially for adult animals.

Table1. Recommended Ventilation Rates in cubic meters / minute / animal

Production phase	Minimum	Mild weather	Warm weather
Sows with litter	6	25	152
Piglets 6 - 12 kgs	0,6	3	7,6
Piglets 12 - 35 kgs	0,9	4,5	13,7
Fatteners 35 - 70 kgs	2	7,3	23
Fatteners 70 - 130 kgs	3	10,6	36,5
Gestation	3,6	12	76,2
Breeding	4,3	15	91

Because in a gestation chamber, there are sows at various stages of pregnancy, the design must be careful, so to help the prevention of heat stress. The first 30 days and the last two weeks of pregnancy are the periods where thermal stress can have the most critical negative effect on litter size and survival of piglets.

Pregnant sows start experiencing thermal stress, when the ambient temperature is greater than 28°C. Heat loss by evaporation from the skin of the pig is minimal and for this reason exceptionally effective methods to reduce temperature must be used. The basic tools - methods that are used in various combinations, for cooling pregnant and replacement sows are shading, air circulation, and some type of spraying systems with water or with the use of cooling panels. The most reliable method of controlling air movement during hot weather is the mechanical ventilation of the room rather than a physical way as wind is meager during the hot summer months. Efficiency will be higher by using air cooling methods. The incoming air stream passes through a fluid bed (panel), and because of air heat, the moisture from this layer evaporates. Although the relative humidity in the building increases, the dry air temperature is reduced. The effectiveness of these systems depends on the relative humidity of the outside air. The comparisons between different approaches is difficult due to weather differences in each region, but the cooling systems work best in hot, dry climates, while spraying of animals and evaporation of water work best in humid climates.

The maintenance of the ventilation system is necessary in each chamber. This should include cleaning of fans (vanes and louvers) to remove dust. Louvers must be cleaned from both sides to open easily.

The activation of the cooling systems should be based on Scheme 1. Check and repair of cooling panels, nozzles, emitters, louvers, etc. must be done before temperature becomes too high. Dust should be removed particularly from panels and they have to be tested for the deposition of salts. It is advisable to measure the amount of air passing through the panel to ensure the necessary ventilation. Measurement of outdoor temperature and relative humidity will help to achieve the optimal system configuration. It is proposed to start operating the cooling systems when the temperature reaches 25,5^{o}C in farrowing rooms and 24 °C in pregnancy. The fans should always work before the start up of the cooling systems.

Semen and breeding management

Generally, all animal activities should be programmed either in the morning or in the evening hours, to reduce stress during the hottest hours of the day.

Concerning semen, the minimum and maximum storage temperature must be checked daily. To have more accurate measurements, it is recommended that the sensor is placed in a container with water, so the measurements are not affected by the opening and closing of the semen cabinet. The temperature in the premises where the diluted semen is kept, should be 21-22°C in order not to affect the proper operation of the cabinet. If the semen is purchased from an external supplier, the temperature should also be check, depending on the package. The insemination should be done early in the morning, before the rising of the temperature. Boars -detectors used for stimulation of oestrus, should only be used for 30-45 minutes, to ensure that a sufficient amount of pheromones

is available to stimulate females. To improve the libido of these boars it is suggested to conduct either a mating or a semen collection per week. During the process it is advisable that the boar-detector is exposed to small groups of sows and insemination is done as soon as possible. If sows are thin, flushing is recommended. Also, it would be better if more personnel are involved in this sector at such times to complete the process as early as possible.

Sows management

Administratively, the negative effects of heat stress can be reduced by placing cooling systems, if there are not any. Also, the body condition of sows entering the farrowing room must be controlled more intensively, to avoid having overweight animals in summer time. Flow control should be done on all drinkers. If it is necessary, time should be devoted to thee training of firstborn sows in the use of a drinker. Water is an important factor in feed intake. It should not only be always available to sows but should have a temperature up to 15°C and a flow rate of about 2 litres per minute, with a minimum of 1.5 liters / minute. If there is a water tower this should be insulated and protected to maintain the water temperature at an ideal level.

Increase of the temperature from 15 to 16°C to 30°C will increase water consumption by the sows of over 50%. A rule of thumb is to maintain a water to feed ratio of 5: 1. A sow usually consumes 9-18 litres in gestation and twice in lactation. These quantities may be doubled in warm periods. The existence of a pressure pumps and moreover a second (backup unit) is necessary. It should be noted that the quality of drinking water is an important factor. Finally, optimal conditions must be present in the places where replacement sows are kept so as not to affect their reproductive behaviour.

Facing heat stress through nutrition

Apart from environmental control, nutrition of sows has an important role in their productivity during summer. It is a fact that there is a direct correlation between heat and reduced feed intake. Thermally distressed sows eat less because the process of digestion increases their body temperature.

Lactating sows will retain their litter and then utilize the nutrients from the feed to maintain their body condition. This means that sows that are not eating enough can lose their body condition faster. A malnourished sow is less likely to be reproduced with the usual rates so they need to remain in good condition.

Technical solutions to reduce heat stress are often time consuming and expensive, e.g. installing cooling systems in plants. A nutritional approach may be proven more adaptable and faster to implement. Based on the information available there are ways of improving the productivity of pigs during heat stress periods.

The most common measure is the use of denser diets. This applies to the energy content of the diet and is being done to compensate for the reduction in feed intake in lactating sows. Using more attractive feed and generally increasing the attractiveness of the diet has a positive effect. These measures include the preparation of wet rations if the proper attention is given to avoid spoilage of feed due to heat. Also the use of pellets instead of mash feed.

Replacement of starch with fat as an energy source. Fats are excellent sources of energy for pigs to compensate for the reduction of feed intake. Fat is also a more digestible component and produces less metabolic (endogenous) heat during digestion compared to starch.

Reducing the level of crude protein in the diet. Study on nursing sows under heat stress, showed that, they lose less weight if their diet contains a lower amount of crude protein (Table 2. Noblet et al, 2000). The explanation is that in the course of digestion, proteins generate more endogenous heat than fats (26% vs. 9%), because of the complex reactions required for the metabolism of amino acids, the proteins are consist of.

Table 2. Effect of the level of crude protein in the diet with respect to the temperature in sow productivity

Temperature	**20 °C**		**29 °C**	
Crude protein (%)	17,6	14,2	17,6	14,2
Feed intake in kg / day	6,71	6,51	3,56	4,05
Piglet weight at weaning	10,5	10,3	10,4	10,3
Milk production in kg / day	10	9,6	7,4	7,7
Sow weight loss in kg	16	15	41	29

Less fiber. The higher the content of a feed and thus a ration in crude fiber, the harder is to digest. Not digested fibers reach the colon where stimulate the growth of micro organisms (especially when there are also available undigested nitrogenous substances and amino acids), which generate heat from the fermentation processes.

Adjustment of feed portions. As mentioned above, the digestion of feed causes endogenous heat production, which affects body temperature. Large meals induce these phenomena. Providing smaller and more frequent meals during the day and / or feeding at night and early morning, reduce overall endogenous heat production.

The transition from 2 large meals to three smaller, increases total feed consumption by 10-15%. In some cases, ad libitum feeding could be applied to lactating sows. Today, there are some computerized feed delivery systems that can help. In this case, special attention should be paid to the amount of the meal and the frequency of administration, so that feed does not remain for long time in the trough and get degraded due to high temperatures. The feeders should be kept clean and supplied feed to be always fresh.

Maintaining acid-base balance. With increasing temperature, the intensity of respiration of the animal also increases. The faster breathing, takes more carbon dioxide from the blood stream which then is exhaled. This changes the pH levels in the blood, leading to metabolic acidosis and lower feed intake. The addition of sodium or potassium bicarbonate can help in restoring acid-base balance and increased feed intake.

Use of additives to increase the antioxidant substances of the diet. The simplest measure is the addition of an extra amount of vitamin E, C, and betaine. Also the use of acidifiers can help to adjust the pH of the body and the digestive tract. Enzymes such as amylase, protease, xylanase, etc., increase the density of the diet and reduce the "cost" of ingredients digestion. Various manufacturers suggest various formulations, claiming they help in this direction, in conjunction with increasing the attractiveness of feed, reduce inflammatory reactions etc.

Reassessment of participation levels, for trace minerals, vitamins and amino acids. All this should be in balance with the energy content of feed. In the case of amino acids, it was mentioned above that their excess leads to growth of micro organisms in the colon, with negative consequences on the health of the animal and increased production of heat. As for the other nutrients, many researchers consider necessary, to increase their inclusion levels in periods of heat stress.

Dealing with toxins that adversely affect animal health. The warm and humid weather increases the likelihood of contamination by mycotoxins inside and outside the unit. In heat stress conditions, the liver of the animals is often under pressure. This appears as a poor use of nutrients and / or chronic inflammation of the liver. It is important to maintain the liver as healthy as possible and avoid further stress by toxins, e.g. mycotoxins.

Alternatives to Cereals and Soybean Meal

Ioannis Mavromichalis,

PhD, International Consulting Nutritionist – Chief Editor of "Pig International", USA

High prices for common cereals and soybeans come and go since ancient times. The only certain about it is that their cycles will continue and what better times to consider alternatives now that prices appear to be normal. After all, when everybody will be looking next for alternatives, when prices will be again high, it will be too late to find and test sources of alternative ingredients.

Feed cost used to make up at least 60% of the cost of raising a pig. When prices for common cereals and soybeans are too expensive, this figure can reach 80%. So, to start with, the general idea is to improve the feed to gain ratio, or feed efficiency. Anything that reduces the amount of feed required per unit of weight gain, it also reduces feed cost per unit of gain. The following are some general ideas regarding non-nutritional and nutritional strategies to control, if not lower, feed cost.

GENERAL CONSIDERATIONS

The following are some general ideas regarding non-nutritional and nutritional strategies to control, if not lower, feed cost.

Purchasing

It is a business axiom if you want lower prices you have to buy more or buy for a longer period of time. It makes sense to assume that increasing purchasing power (either increasing the volume per transaction or the duration of a purchasing contract), lowers prices per unit of weight. Back in 2004, when cereal prices became unreasonably high for the first time, several producers had already made 10-year contracts with cereal producers to lock in prices ahead of the forthcoming crisis! The DDGS era brought expensive cereals and this problem will persist for the foreseeable future.

Pig Market Weight

It is also well known that when feed is expensive, pigs should get to the market sooner. Pigs tend to deposit more and more fat after their protein deposition potential peaks. This affects adversely the feed/gain ratio, meaning that weight gained late in life is not as efficiently gained as weight earlier on. This is just a matter of fact due to the greater energy required to deposit one gram of fat compared to one gram of lean tissue! To find the optimal market weight the use of a modern model (such as InraPorc, which I use constantly) can be of tremendous value, but on average, feed/gain starts declining rapidly after about 80-90 kg body weight. This issue is very important for early maturing pigs that deposit mostly fat tissue after 80-90 kg body weight.

Leaner Genetics

Through the same mechanism of depositing less fat, as described above, leaner genetics can offer substantial feed cost savings! Leaner pigs cost less to produce and this solution might be as easy as switching the genetic make up of your terminal sire semen supply. Keep in mind that some Pietrain crosses usually suffer from very low feed intakes and this coupled with below-average health conditions, and high summer temperatures, may markedly reduce growth performance. Alternatively, selecting for late maturing pigs will reduce the problem of overly fat pigs, but these genetics tend to be slower in growth rate (take more days to reach market weight).

Feed wastage

If around 25% of feed is wasted through poor management of feeders, feed, and pigs, it is a golden opportunity to resolve this chronic issue by training personnel, fixing feeders, and reallocating feeders. Each percentage unit wastage is reduced is a percentage unit savings in feed/gain ratio! Most farms don't even realize the extend of wastage until it is actually measured. Wastage around 10% is considered normal in most farm, but with careful management this figure can be reduced to below 5%.

Animal Health

It is no secret healthy pigs grow leaner and more efficiently compared with pigs of suboptimal health. Malnutrition early in life is also "compensated" by depositing more fat and organ tissue later when nutrition becomes normal again. So, it pays to keep animals healthy and thrifty! A good start also ensures profitable feed/gain later on. To this end, investing in a high quality (expensive) prestarter will ensure pigs start eating and growing as soon as possible after weaning.

Additives and Return-on-Investment

This is quite easy to accomplish with the help of a qualified nutritionist. Additives should be evaluated based on return on investment. Usually, additives that improve growth below 4-5% are difficult to justify during hard times. Cast a critical eye on additives and question whether they really are worth the expense and trouble. Use only the ones that really work in your farm. Not all additives work in all farms!

Feed Particle Size

It has been determined by pioneering work done at Kansas State University by Dr. Joe Hancock's laboratory that for every 100 microns reduction in particle size, feed efficiency improves by 1.4%. As an example, assume that now you grind your cereals at 900 microns (medium-coarse) and you achieve a 2.9 feed/

gain ratio in the finishing barn. If particle size is reduced to 600 microns, feed efficiency is expected to be improved by 4.2%, down to 2.68. Of course, this improvement in feed efficiency should not be outweighed by the cost of grinding cereals to such reduced particle size! In wheat-based diets, ulcers don't start to become problematic in stressed pigs until particle size is reduced below 600 microns. Grinding soybean meal has not resulted in improved pig performance.

Enzymes

Here, I am considering enzymes against the major non-starch polysaccharides found in cereals, especially in wheat (arabinoxylans) and barley (beta glucans). Data for maize-based diets are unclear, at best! But, for diets based on wheat and barley, particularly if these cereals are of poor quality (as defined by a large concentration of non-starch polysaccharides), the addition of a cereal-specific enzyme should increase metabolizable energy concentration by about 50 kcal/kg complete feed. Effects on protein digestibility are not so well documented, so it's recommended to base your calculations on energy savings alone. Again, the cost of using such an enzyme should not be outweighed by the cost of providing a similar amount of energy through other sources (lard, tallow, soy oil, etc).

Mycotoxins

Pigs invariably suffer from lower performance when fed diets even with low levels of mycotoxins. It is best to determine the predominant mycotoxins for the cereals you use and then apply a specific product, instead of using a blanket approach that usually costs more and does not cover region-specific mycotoxin problems. For example, maize from the Americas is often contaminated by aflatoxins, but maize grown in Europe usually suffers from a host of totally different mycotoxins! If your sources of cereals are variable, then it is best to use a coctail of anti-mycotoxin agents with a wide spectrum of coverage.

Balanced Diets

This is easier said than done, as it requires the use of a growth model to compare nutrient requirements versus nutrient supply. And, this is the first step! Then, a qualified nutritionist is required to assess the changes needed to match the two together in an effort of cutting cost by reducing excesses, covering deficiencies, or preferably both. INRA (France) has recently released such a growth-nutrition model (InraPorc), which appears to be quite promising, especially in the hands of a qualified nutritionist!

Pelleting?

Indeed, pelleted feed is most likely to improve feed/gain by 5 to 15% depending on diet nutrient composition, ingredients used, and of course, the weight class of the animals. For example, greater improvements are expected in younger animals. As always, the extra cost of pelleting should not be greater than expected benefits, especially when the price of fuels is extremely high!

ALTERNATIVE CEREALS IN PIG FORMULAS

Usually this is the first solution that comes in mind when cereal prices go up. But, unless you lock in a large quantity of such alternatives before the market adjusts, it is highly unlikely such ingredients will remain price competitive for long. It is a fact in world trade, when the prices of reference ingredients increase, then prices of alternatives also increase just below the point where the use of such alternatives is no longer financially rewarding.

Wheat, of course, is the grain of choice for pig diets in most of Europe, Canada, and parts of Asia and it is frequently used up to 100% of the cereal portion of the diet (in other words, wheat is often the only cereal used). Apart from slightly lower energy content than maize, wheat is rarely the cause of any real problems (Table 1). Actually, some preference studies demonstrated that wheat is the cereal of choice for piglets, when compared to corn, barley, and oats. However, there is a great amount of variability among wheat varieties and even batches of the same variety. Wheat can be infected by mycotoxins, like most cereals, and also contains relatively mild levels of anti-nutritional factors, mostly arabinoxylans, which reduce its nutritive value. To this end, when varieties with high levels of arabinoxylans are used, an enzyme (xylanase) is often recommended, especially if wheat is the major cereal in a diet. Fine grinding (500 μm) of wheat will improve nutrient utilization but will also cause feeder bridging when diets are fed in meal form. It may also aggravate ulcer problems in stressed pigs. On the other hand, coarse grinding (1200 μm) will result in lower digestibility and increased nutrient excretion. Thus, medium grinding (600 μm) seems to be preferred for many reasons. Soft and hard varieties have been shown to support equal performance in pigs, when of equal quality.

TABLE 1
Feeding wheat or maize to nursery pigs [1]

	Maize		Wheat	
Performance	Raw	Cooked	Raw	Cooked
Days 0-7 post-weaning				
Weight gain (g/day)	142	137	141	129
Feed intake (g/day)	193	199	188	172
Days 0-21 post-weaning				
Weight gain (g/day)	286	283	285	304
Feed intake (g/day)	488	430	460	447

[1] A total of 160 pigs (14 days of age and 4.3 kg) were used in four replicates per treatment.
[2] Cereal source and thermal processing had no effects on growth performance.

Adapted from 'Applied Nutrition for Young Pigs', 2006, I. Mavromichalis, CABI.

Sorghum has been traditionally considered undesirable for pigs and especially for nursery diets because of its high tannin content. In the past, it was only fed in cases where maize was unavailable or growth performance losses outweighed the extra cost of feeding maize-based diets. Growth depression is caused by lower nitrogen digestibility as indigestible tannin complexes are formed in the intestinal lumen. However, newer sorghum hybrids have considerably lower tannin levels compared to the older bird-resistant varieties. Thus in many recent studies using both simple and complex diets, sorghum grain has been used without the growth performance loss or palatability problems seen in earlier experiments. In a recent study, when sorghum varieties were compared based on their hardness, soft varieties outperformed hard ones in terms of growth performance and nutrient digestibility (when ground to an average particle size of 500 μm). It has been, thus, suggested that new low-tannin, soft sorghum grain cultivars can replace totally maize even in nursery diets. In any case, it is suggested that sorghum should never replace wheat or maize suddenly but only in a gradual manner, and when tannin concentration is unknown, sorghum should not exceed 50% of the cereal portion in gestating and finishing diets, and 30% of the cereal portion in lactation and nursery diets.

Rice is grown mainly for human consumption and as a result its use in pig diets is rather limited. However, when good quality rice flour (no hulls) was fed to nursery pigs performance was equal or even better when compared to the performance of maize-fed piglets. Paddy rice and rice hulls are not recommended for young pigs. On the other hand, full fat rice bran has been fed (up to 15%) in weaner diets with no negative effects. Oil rancidity may be a problem in this type of diets, though. In conclusion, besides price and quality, no real problems should arise from the use of white rice in nursery diets. For older pigs, broken rice may occasionally become available locally, and this can be freely fed to pigs without any problems replacing 100% of all other cereals.

Oats are high in crude fiber (12%) and consequently low in energy. This fact has been reflected in many studies where dietary levels of up to 30% markedly reduced post-weaning performance of piglets offered simple diets. However, higher concentrations (up to 50%) were better tolerated when diets were pelleted. Today, not much oats are fed to young pigs mainly because oats is a valuable commodity for the human food industry and thus relative expensive. On the other hand, naked oats have been reported as able to totally replace maize in well balanced complex nursery diets. Although there is little scientific evidence of any beneficial effects of oat groats over maize in high nutrient density diets, they can be easily found in many nursery diets. The use of oat groats or other products (e.g., oat flour) should be a purely price- and(or) marketing-based decision, when complex diets are in question. For older pigs and breeding animals, specialty oat products like those used in piglet feeds are not economical enough to be used. However, whole oats are often available at reduced prices and these can be used up to meeting the crude fiber content of the diets, which should not exceed 5% in most cases. Thus, whole oats are frequently limited to 50% or less of the cereal portion of such diets.

Barley is also high in fiber and has a high β-glucan content, which altogether make it rather unsuitable for nursery diets, but it is used quite tolerably in other pig formulas, almost invariably with wheat. Enzyme (beta-glucanase) supplementation has been shown to enhance growth performance in some studies, but its effects are less profound in pigs than in broilers, and certainly have to do with the quality of barley. Hulless barley is another option but its nutritional value is still not comparable to maize because of the high β-glucan concentrations present specifically in hulless barley. Two-row cultivars have been shown to have a lower nutritional value than six-row varieties, especially in young animals. All in all, barley is better held off post-weaning diets. In later nursery diets (above 10 kg of body weight) a growth performance drop should be anticipated from feeding barley, but above 20 kg of body weight barley can be used up to meeting the crude fiber specification of each feed. If barley is the sole or major cereal, then fat or oil must be also used in enhanced concentrations to make up for the deficit in energy, and in addition the use of a suitable enzyme is strongly recommended.

Triticale has been blamed for unpalatability, ergot infestation, and high pentosan concentrations that made early cultivars undesirable for weaned pigs. However, recent varieties have been used with great success in rather simple nursery diets. It has been reported that triticale should be included in nursery diets to replace no more than 50% of the grain share. In other pig formulas, triticale may be used without limitations but actual levels should be monitored because of the variability in quality. As triticale is a cross between wheat and rye (see below), it is high in pentosans and as such it needs enzyme fortification (a xylanase like in the case of wheat is sufficient).

Rye is extremely high in pentosans. Feeding weaners with rye-based has shown variable results, with feed intake depression as the most common finding. Dustiness problems may also arise from feeding high-rye diets in meal form. Supplementation with pentosanases has been shown to somewhat increase pig performance but not to the levels supported by maize- or wheat-based diets. Ergot infestation is a major concern in rye and great care should be taken for such batches not to reach nursery diets. It is, thus, advised that rye should be gradually introduced into diets destined for pigs over 10 kg with final levels of no more than 10 to 15%, depending on quality. In finishing pigs and breeding animals rye, depending on quality, should never exceed one third of the total cereal fraction.

Table 2: Comparative Nutritive Value of Cereals

Cereal	Net Energy MJ/kg	Crude Protein %	Crude Fiber %
Maize	11.1	8.1	2.2
Wheat (soft)	10.5	10.5	2.2
Rice (wheat)	12	8	0.5
Oats (whole)	8	9.8	12.2
Triticale	10.3	9.6	2.3
Rye	9.9	9	1.9
Barley	9.5	10.1	4.6
Sorghum	11	9.4	2.4

Adapted from ‘Tables of Composition and Nutritional Value of Feed Materials’, 2004, INRA.

General Considerations

Cereals should never be replaced on a 1:1 weight for weight basis because all cereals don't have the same nutritive value (see Table 2). As such, 100 kg of maize should never be replaced in any formula with 100 kg of wheat, even if the wheat is of the highest quality. If this happens, then animal performance is most likely to suffer. Diets with alternative cereals should be balanced properly for energy, amino acids, and minerals. It is strongly suggested that the Net Energy system is used and the amino acids are balanced on the Standardized True Ileal Digestibility basis. This is important because other systems are based on common cereals and they are prone to under- or over-estimate new cereals. Any qualified nutritionist should be able to use these new nutritional tools without problems and as such seeking such assistance is strongly advocated. In addition, when changing cereals, mycotoxins are rarely the same! Thus, the correct anti-mycotoxin agent should be identified and used at the proper level. For example, the major mycotoxin in maize from the USA is aflatoxins, and for these a sepiolite product is sufficient. In contrast, the same product is completely ineffective when wheat from Ukraine infected with vomitoxin is used. Finally, the degree of grinding fineness and the handling characteristics of the ground cereal and feed should be well established before these cereals are purchased to avoid unpleasant surprises, such as feed stuck in silos, and loss of performance (Figure 1).

Figure 1
Wheat particle size affects greatly performance in young pigs.

Adapted from 'Applied Nutrition for Young Pigs', 2006, I. Mavromichalis, CABI.

ALTERNATIVES TO SOYBEAN MEAL

Prices of soybean meal and crystalline amino acids remain volatile. From time to time, there is considerable interest for less well known protein sources, either because of availability or reduced price opportunities. When such cases arise, it is important to know two key elements: anti-nutritional factors that need to be evaluated, and maximum inclusion rate for each class of pigs. This information along with the nutrient profile will help the nutritionist determine the level at which such alternative protein sources can contribute in existing diets to reduce feed cost without affecting animal performance. Below is just an introduction for some common alternative protein sources. The figures suggested are for 'educational' purposes and should not be used without consulting first with a qualified nutritionist that knows first-hand the raw material in question and the farm/animals where they are to be used.

Rapeseed

Rapeseed *(Brassica napus and Brassica campestris)*, a member of the same family as mustard, cabbage, and turnips, is a major oil yielding crop, being third after soybeans and palm. It is cultivated in regions with colder climates that are usually unsuitable for growing soybeans.

Regular varieties of rapeseed contain high levels of anti-nutritional factors that cause problems in all animals. These factors include glucosinolates (goitrogenic), erucic acid (toxic), tannins, sinapine, phytic acid, and mucilage. The most important for animal production is glucosinolates that reduce feed palatability due to their 'hot' and pungent taste (same as mustard and horseradish).

As these anti-nutritional factors are not greatly affected by heat treatment, it has been only through plant breeding that their presence has been significantly reduced. Modern varieties of rapeseed that are low in glucosinolates or erucic acid are often referred to as 0-rapeseed. Those low in both glucosinolates and erucic acid are referred to as as 00-rapeseed. The latter is the most common variety used today worldwide for oil production for human consumption.

Feeding normal rapeseed meal (not double-zero). If rapeseed with normal (higher) levels of glucosinolates and erucic acid is to be fed to pigs, then naturally, usage must be limited to avoid reduced performance and ensure animal health. Normal rapeseed meal should be used only in diets for finishing pigs (above 60 kg live weight) and gestating sows. In both cases, a maximum inclusion rate of 10% is recommended.

Feeding 00-rapeseed meal. Rapeseed meal from 'double-zero' varieties (including authentic Canadian canola) can be used more freely than normal rapeseed meal. In such cases, it is best to first limit inclusion of 00-rapeseed meal up to 25-50% of current soybean levels. In reality, this has been proven often to be the best case scenario. Although there are several research reports where 00-rapeseed meal has successfully replaced soybean meal 100%, in practice this should be avoided unless its quality is assured and diets are balanced and double-checked by a qualified nutritionist.

In more practical terms, 00-rapeseed meal may be used safely up to 5-10% in young pigs and up to 15-20% for older pigs. Well balanced diets for gestating sows can be based solely on 00-rapeseed meal as the major protein source (zero soybean meal diets). Diets for lactating sows should include no more 00-rapeseed meal than is necessary to reach the maximal crude fiber specification.

Maize gluten

Maize gluten is a by-product of the starch industry. Maize gluten meal is basically just the protein gluten, where maize gluten feed is gluten plus hulls. There are three maize gluten products available in the market today. Maize gluten meal with 60% crude protein containing no hulls. Maize gluten feed with 20% protein contains all hulls from the starch production process. And, finally, maize gluten meal with 40% protein, being a blend of the other two products, or a blend of gluten and half the hulls.

Feeding maize gluten products. Due to low energy content, maize gluten feed is best avoided in diets for piglets. On the other hand, assuming diets are properly balanced for all amino acids, including valine and isoleucine, maize gluten meal at 60% crude protein can be used up to 10% in diets for piglets. Older pigs and sows can consume diets containing up to 20% maize gluten meal, but less maize gluten feed (to the point where diets are balanced for energy and amino acids). Of course, these are general, conservative numbers. Under proper nutritional guidance, up to 30% or even more maize gluten meal/feed can be used in certain diets. Indeed, a study conducted at the University of Kentucky indicated that up to 80% maize gluten feed can be used in diets for gestating sows without any problems.

Sunflower

Sunflowers *(Helianthus annuus)* are grown mostly in cold climates for their seeds. These are used for oil production or as a confectionary item. There are distinct varieties for each use because confectionary seeds are not rich enough to be used for oil production. Sunflower meal is the residual matter after oil extraction, usually by the use of solvents (as in the case of soybeans), but also by hydraulic pressure (old method). The latter method produces sunflower meal rich in residual oil, and this should be taken into account during feed formulation.

All pigs will readily consume diets based on sunflower meal. This is due to the fact that sunflower meal contains a small amount of sugars, which give a sweet taste to pig feed. This is very important in piglet feeds where a sweet taste is often simulated by the use of artificial chemical sweeteners. Sunflowers contain no known anti-nutritional factors, in contrast to other protein sources such as soybean meal that contains a plethora of such compounds. Nevertheless, the use of sunflower meal in pig diets is restricted by its concentration in crude fiber, something that is considered undesirable in diets for piglets, growing pigs, and lactating sows - at least when crude fiber concentration exceeds 3-5% in the final complete diet.

Sunflower meal is available commercially in three forms, depending on the level of hulls in the final product (see Table 3).

Table 3
Types of commercial sunflower products for animals.

Typical Analysis	Protein (%)	Oil (%)	Fiber (%)
Whole seeds	14-16	28-45	16-28
Sunflower meal	28	1-2	25
Partially dehulled meal	33	1-2	21
Dehulled meal	38	1-2	14

Dehulled sunflower meal, that contains no hulls. This has about 38% crude protein and 14% crude fiber. This is the preferred type of sunflower meal for piglet and lactation diets.

Partially dehulled sunflower meal, that contains a part of the hulls. It contains 32-35% crude protein, and 20-25% crude fiber. The exact levels depend on the concentration of hulls. This product is suitable for growing pigs and gestating sows.

Standard sunflower meal, that contains all the seed hulls. Here, the crude protein concentration is usually less than 30%, with around 25-30% fiber. This product should be avoided in diets for piglets, and used only sparingly in diets for lactating sows and growing pigs. In contrast, it can be a very useful ingredient in diets for gestating sows that require a high level of crude fiber - especially for group housed sows fed ad libitum.

Sunflower seeds (full fat) are often available for animal consumption after being discarded by the oil or confectionary industry for a number of reasons pertaining to their quality. Whole seeds contain about 16% crude protein, 45% oil, and 16% crude fiber. Research conducted in the 80s has demonstrated that the high fiber content makes whole seeds equally unsuitable with sunflower meal when used in high concentrations in pig diets. But, in addition, it appears the high oil content in full-fat seeds creates further feed intake problems, related to palatability, even in cases where a high-fiber concentration was not a major concern, such as in gestating sows. Thus, it has been proposed to reduce the inclusion level of full-fat sunflower seed to 10% in piglet diets and diets for growing pigs, and to 25% in lactation and gestation diets.

Minor legumes

Fababeans *(Vicia faba)* is a legume related to the garden beans (those beans consumed by humans). The are two major types of fababeans: those from white-flower varieties and those from colored-flower varieties. Their chemical composition and nutritive value is about the same, but the colored-flower varieties contain more tannins. Tannins (usally about 0.3 to 0.5%) reduce feed intake, and depress digestibility of protein and energy. Other major anti-nutritional factors in fababeans include trypsin inhibitors (at levels below those found in raw soybeans) and hemagglutinins (at levels many times those found in raw soybeans).

The presence of these anti-nutritional factors make necessary the use of raw fababeans in limited levels in diets for pigs. The maximum level below which problems are few is around 15%. In diets for young pigs, this level should be 5-10%. It is possible to feed up to 20% fababeans in diets for finishing pigs, but if the fababeans are from colored-flower varieties, feed intake will be reduced. Feeding high levels of fababeans creates a large volume of gastrointestinal gases that cause constipation in lactating and gestating sows. In general, fababeans should be introduced gradually in pig diets starting from 5% and not exceeding 20%.

Field peas *(Pisum sativum)* are grown mainly for human consumption, but large quantities are made available for livestock feeding due to many reasons (quality, over-production, prices, etc). Like all legumes, field peas contain several anti-nutritional factors, of which the most important are: trypsin-inhibitors, hemagglutinins, and cyanogenic glycosides, in order of importance. Nevertheless, in most cultivated varieties, these anti-nutritional factors are in such low levels that they do not pose a great level of risk when peas are fed raw, that is without any heat-treatment. This is especially true, when inclusion levels are rather low, and the animals are either of progressed age (finishing pigs) and used to eating peas from earlier in life.

In diets for piglets, the maximal inclusion rate of raw peas is 15%. Above this level, feed intake drops and growth is impaired. In some cases, higher levels can be used if digestible tryptophan levels in the whole diet are properly balanced. For growing-finishing pigs, field peas can totally replace soybean meal, as long as the diets are balanced in energy and amino acids. For breeding pigs, results are mixed, and when using varieties with high levels of anti-nutritional factors, breeding performance can be impaired when feeding more than 10% peas. In some studies, feeding up to 25% field peas did not affect reproductive performance.

Lentils *(Lens culinary)* become occasionally available to the animal industry, especially when they suffer from quality problems (such as frost damage, discoloration, or seed damage). Nevertheless, these issues do not pose any problems when such lentils are fed to pigs of all ages. Care should be taken when using lentils: the diets should be balanced on digestible amino acids, because not all crude protein in lentils is true protein - lentils contain about 7% non-protein nitrogen!

The major anti-nutritional factor in lentils is protease inhibitors, but these are not present in sufficient quantities to depress pig performance. Thus, up to 30% raw lentils have been used with success in growing finishing diets (Table 4). Nevertheless, in diets for very young pigs it is always prudent to use conservative levels, starting at no more than 10% in high quality formulations.

Table 4
Feeding lentils to growing pigs

	Lentils added in diets for 23-100 kg pigs			
Item	0%	10%	20%	30%
Weight gain (g/day)	820	830	860	860
Feed intake (g/day)	2530	2480	2560	2580
Feed efficiency	3.09	2.99	2.98	3.00

Adapted from Bell and Keith (1986), Canadian Journal of Animal Science, 66:529.i

Nutrition and its effectiveness in practical applications in commercial units.

Association of the production of pig meat with Renewable Energy Sources. Optimization of production cost.

Angelos Kachrimanidis,

Veterinarian, ***President and C.E.O of Vethellas S.A.***

The pig industry is a particularly important activity of the agricultural sector of the EU, it constitutes 11% of the European agricultural production (European Commission, 2003). In Greece, the pig industry is considered as a dynamic sector of the rural economy as it contributes by 30% in the total meat production although it covers less than 25% of the annual requirements in pig meat. Since the 1960s, with the implementation of governmental funding programs and financial aid, the Greek pig farming began to develop and changed from domestic type of business to industrial. Since 1995, the industry is clearly oriented to enterprise structures and intense concentration of livestock (Batzios, 2001). Despite improvements made in the recent years, all pig farms have weaknesses, which certainly are due to the small business development rates of the sector. These weaknesses have resulted in reduced competitiveness of the Greek pork in relation to the European. The competitiveness of the Greek pig farming can be improved by increasing productivity and by reducing the total cost of production.

The rearing costs of swine is related to the total production of pig meat per sow (yield), the average number of sows in production, the average daily gain of pigs and feed conversion (Kitsopanidis, 1999).

Over the last years, pig meat production is declining, while the consumption remains elevated. The highest production was achieved in 1987, with 163.789 tons, according to the data from the Ministry of Rural Development. Thereafter a steady decline in the Greek production of pork followed, to reach in 2011, 119.519 tons, while today, according to market players, the domestic production of pork reaches 60-70.000 tons, while imports of this meat amounted to 250.000 tons, (without including the quantities intended for the delicatessen meat industry and meat processing plants). Thus, the dependence of our country on imports is growing more and more, and widens the deficit balance. The amounts of money flowing out of the country are calculated based on of the above and are over € 0.5 billion a year. If we also calculate the amount which is required by the meat industry, then, the total amount needed for pig meat imports reaches one billion €.

The consumption of pork, per capita, in Greece is about 30 kg per year, when the annual consumption of pork in the European Union is higher and is expected to exceed 45 kg per capita in the near future.

Moreover, growth trends of pork consumption are recorded in Central and Eastern Europe, despite the current economic crisis.

Several studies even argue that, in the next 10 years, the pork will be the first choice of meat worldwide.

According to the literature, the main factors shaping the overall production cost in a pig farm are the following:

1. The feeding cost
2. The labor cost and social security contributions
3. Expenditure for medicines, vaccines and disinfectant products
4. Bank loans and annual assets amortization
5. Energy cost
6. Equipment Maintenance Costs
7. Miscellaneous - unexpected expenses

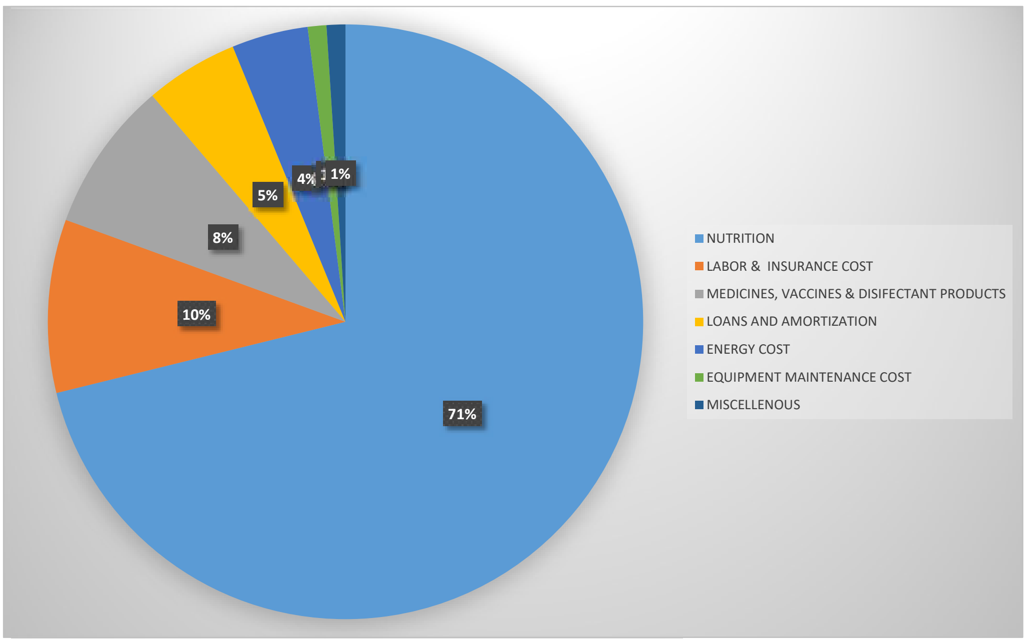


Chart 1. Percentage contribution of cost factors in a pig farm

Nutrition is the biggest factor, shaping almost 64 - 72% of the production costs, depending on the current feed prices (Interpig report 2014).Feed prices have wide variations not only between different countries but even in the same country during the year (AHDB Pork, 2014).

Table 1. Meat production cost for carcasses type 79% in some countries, 2014 (in GBP)

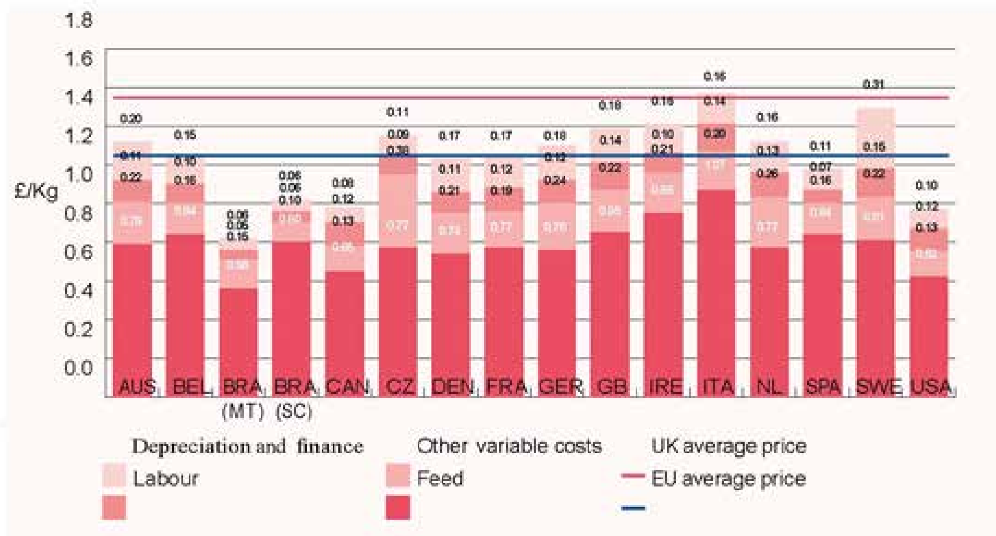


Table 2. Summary of economic meat production factors for 79% carcasses type in certain countries, 2014 (in GBP)

	AUS	BEL	BRA (MT)	BRA (SC)	CAN	CZ	DEN	FRA	GER
Τροφή	0.79	0.84	0.56	0.80	0.65	0.77	0.74	0.77	0.76
Άλλο μεταβλητό κόστος	0.22	0.16	0.15	0.10	0.13	0.38	0.21	0.19	0.24
Σύνολο μεταβλητού κόστους	1.01	1.00	0.71	0.90	0.78	1.14	0.95	0.96	1.00
Εργατικά	0.11	0.10	0.05	0.06	0.12	0.09	0.11	0.12	0.12
Αποσβέσεις και χρηματοδότηση	0.20	0.15	0.06	0.06	0.08	0.11	0.17	0.17	0.18
Σύνολο σταθερού κόστους	0.32	0.25	0.12	0.12	0.19	0.20	0.28	0.29	0.30
Γενικό Σύνολο	**1.33**	**1.25**	**0.83**	**1.02**	**0.97**	**1.34**	**1.23**	**1.25**	**1.30**

	GB	IRE	ITA	NL	SPA	SWE	USA	AVE EU
Τροφή	0.85	0.95	1.07	0.77	0.84	0.81	0.62	0.83
Άλλο μεταβλητό κόστος	0.22	0.21	0.20	0.26	0.16	0.22	0.13	0.22
Σύνολο μεταβλητού κόστους	1.07	1.16	1.27	1.03	1.00	1.02	0.75	1.05
Εργατικά	0.14	0.10	0.14	0.13	0.07	0.15	0.12	0.12
Αποσβέσεις και χρηματοδότηση	0.18	0.15	0.16	0.16	0.11	0.31	0.10	0.17
Σύνολο σταθερού κόστους	0.31	0.25	0.31	0.28	0.19	0.46	0.22	0.29
Γενικό Σύνολο	**1.39**	**1.41**	**1.57**	**1.31**	**1.19**	**1.48**	**0.97**	**1.34**

All these are affected by the productivity of each pig farm. The performance parameters that are commonly used to measure the productivity of swine include the average daily weight gain (A.D.W.G.) and conversion ratio of feed to meat (F.C.R.) (Black et al., 2001).

The data below come from farms in Greece and Russia, and the analysis of the production costs will be based on them.

The data below comes from farms in Greece and Russia, and on them the analysis of production costs will be based on.

Table 3. Piglets up to the age of 35 days

Age in days		Age in weeks	Live weight in kgs		Average daily weight gain (ADWG) in Kgs	Feed consumption		Feed consumption for the whole period	Feed ratio	**Weekly weight gain in Kgs**	Weight gain for the whole periodin Kgs	Live weight in the end of the period in Kgs
From	To		From	To		g/ day	Kg / week					
0	7	1	1,00	1,63	0,09	0,01	0,07			0,63		
7	14	2	1,63	3,15	0,217	0,022	0,175			1,52	6,63	
14	21	3	3,15	5,18	0,29	0,035	0,245	5,04	Θ1	2,03		
21	28	4	5,18	7,63	0,35	0,25	1,75			2,45		
28	35	5	7,63	10,08	0,35	0,4	2,8			2,45	2,45	10,08

Table 3 presents the data concerning the weighing body weight and feed intake for piglets from birth up to the 35th day of age. At this period, the feed that is provided is Θ1 (prestarter). It should be noted that the diet program applied is based on providing three diets from birth to the end of the development stage (35 kg L.W. approx.).

Table 4. Development stage

Age in days		Age in weeks	Ζων Βάρος σε κιλά		Average daily weight gain (ADWG) in Kgs	Feed consumption		Feed consumption for the whole period	Feed ratio	**Weekly weight gain in Kgs**	Weight gain for the whole period in Kgs	Live weight in the end of the period in Kgs
From	To		From	To		g/ day	Kg / week					
35	42	6	10,08	12,33	0,321	0,543	3,80		Θ2	2,25		
42	49	7	12,33	14,93	0,371	0,800	5,60		Θ2	2,60		
49	56	8	14,93	18,49	0,508	0,900	6,30	42,20	Θ2	3,56	21,71	
56	63	9	18,49	22,69	0,600	0,500 + 0,500	3,50+3,50		Θ2+Θ3 50%+50%	4,20		
63	70	10	22,69	27,09	0,629	1,300	9,00		Θ3	4,40		
70	77	11	27,09	31,79	0,671	1,500	10,50		Θ3	4,70		31,79

After Θ1 ration mentioned before, follows Θ2 until the 9thweek of piglet's age and finally Θ3 until the 12th. This method is known as Phase feeding and was developed because of the drastic changes occurred in the ability of the digestive system and feed intake after weaning. It involves the administration of several rations for a relatively short time, in order to meet the nutrient requirements of pigs more accurately and economically. The pre-starter ration is based on increased participation of high quality and digestibility feeds and is also fed during the period after weaning. Then, gradually, the high quality and expensive feeds are replaced by less expensive ones and with a lower nutritional value. With this method the nutritional needs of swine are met more effectively and economically.

Table 5. Phase A of Fattening

Age in days		Age in weeks	Live weight in kgs		Average daily weight gain (ADWG) in Kgs	Feed consumption		Feed consumption for the whole period	Feed ratio	Weekly weight gain in Kgs	Weight gain for the whole period in Kgs	Live weight in the end of the period in Kgs
From	To		Fro	To		Γραμμ/ημέρα	Kg/ Εβδομάδα					
77	84	12	31,79	36,79	0,714	1.600	11,20		Θ3	5,00		
84	91	13	36,79	42,19	0,771	1.750	12,25		Πρ	5,40		
91	98	14	42,19	47,89	0,814	1.850	12,95	81,20	Πρ	5,70	34,00	
98	105	15	47,89	53,79	0,843	2.000	14,00		Πρ	5,90		
105	112	16	53,79	59,79	0,857	2.100	14,70		Πρ	6,00		
112	119	17	59,79	65,79	0,857	2.300	16,10		Πρ	6,00		65,79

Πίνακας 6. Β' Φάση Πάχυνσης

Age in days		Age in weeks	Live weight in kgs		Average daily weight gain (ADWG) in Kgs	Feed consumption		Feed consumption for the whole period	Feed ratio	Weekly weight gain in Kgs	Weight gain for the whole period in Kgs	Live weight in the end of the period in Kgs
From	To		From	To		Γραμμ/ημέρα	Kg/ Εβδομάδα					
119	126	18	65,79	71,79	0,857	2.400	16,8		Π	6,00		
126	133	19	71,79	77,84	0,864	2.500	17,5		Π	6,05		
133	140	20	77,84	84,09	0,893	2.800	19,6		Π	6,25		
140	147	21	84,09	90,59	0,929	3.000	21,0		Π	6,50	59,10	
147	154	22	90,59	97,39	0,971	3.100	21,7		Π	6,80		
154	161	23	97,39	104,39	1,000	3.300	23,1		Π	7,00		
161	168	24	104,39	111,39	1,000	3.300	23,1		Π	7,00		
168	175	25	111,39	118,39	1,000	3.300	21,7		Π	7,00		
175	182	26	118,39	124,89	0,929	3.000	21,0	185,50	Π	6,50		124,89

Tables 4, 5 and 6, present the same information for the rest of the growing season and the A and B phase of fattening, respectively.

Table 7. Breakdown of sows feed consumption

Farrowings per year	Lactation length in days	Average feed intake per sow per day	Days inlactation per year	Total lactation feed intake per sow per year	Days in gestation and dry period per year	verage gestation feed intake per sow per day	Total gestation feed intake per sow per year
2,3	28	6,5	64,4	422,5	300	2,7	810

Total feed intake per sow per year = 1232,5kg

Surcharge on F.C.R. (22 pigs to slaughter) = 56 Kg

Total feed consumption per fattener = 313,94 Kg
(Tables 3,4,5,6)
Total feed consumption per fattener including sow feed= 369,94 Kg

F.C.R.Nursing piglets	0,555
F.C.R.Growing piglets	1,94
F.C.R.A'phase of fattening	2,39
F.C.R.B'phase of fattening	3,14
F.C.R. totalperiod	2,53
F.C.R.including sow feed	2,986

Taking into consideration that the measured F.C.R. in the farm level is 3: 1 and the average feed cost, for the Greek case, was about 0,28 €/Kg in 2015, it seems that the feed cost per kilogram of live weight produced is 0,84 €. Compared with the data in Table 2, which refer to feed cost per kilogram carcass (in pounds sterling, with current rate of 1 € = 0,84 £), becomes obvious the non-competitiveness of pig farming in Greece, due to the high feeding cost. Compared to the average costs in Europe (carcasses yield 79% x 0,98 € = 0,77 € / kg L.W.) it seems that the feed cost for the production of a kilo of live weight pig in Greece, is by 9% higher to the European production cost.

Assessment of green energy production per kilogram of pork live weight.

Valuation unit: kw per 1000 kg of live weight.

As mentioned above, the feeding cost represents 65% of the production costs. The main difference between Greece and other European countries, especially the neighboring Balkan countries, is related to grains price, which is on average about 8 cents higher per kilo or 80 € per tone. This is confirmed by the fact that the transport of cereals from the Balkan countries bears an average cost of transport of 5-8 cents, depending on the geographical region of Greece.

In this way, the average charges for the pig meat production is 3 (F.C.R. from Table 8) multiplied by 8 cents ie 0.24 € per kilogram of meat L.W. produced (concern the Central and Southern Greece) while in Northern Greece, because of its proximity to the Balkan countries, the amount is about 0.17 €. By balancing the increased production costs through the profit from the production of green energy as per the above amounts, we can achieve the following:

A. The pig farmer can buy the more expensive Greek cereals at the price derived from the cost of the imported cereals plus the transportation cost, ensuring high selling price of cereals for the Greek farmers.

B. It is ensured that the production cost for the pig farmer is the same as in the Northern European countries.

C. Pig meat production becomes profitable in Greece which, in second phase, can evolve to an exporting country.

D. It gives jobs to the Greek economy by activating a branch of collateral crafts and industries currently not fully operational (slaughterhouses, meat processing plants, crafts and industries of livestock machinery & equipment, construction industry, etc.).

E. For all the above activities, supportive to production, there must be guidelines so that producers, do not start investing in a wrong way, as a result of their lack of the necessary know-how.

F. There must be a connection between the production of animal products (meat, milk, etc.) with compensation.

Based on the above, the following options arise for connecting RES with pig meat production:

1) If the price of 1 Kwh is 0.28 €, then 1,000 Kwh are required to balance the feeding cost of 1tonne of pig L.W. Additionally, 200 Kwh of energy are required for the farm's own consumption, or a total of 1,200 Kwh.

This corresponds approximately to a photovoltaic park of 1000 KW production capacity for a 500 sows unit, or 2 kW per sow.

2a) A unit or an aggregation of neighboring units of 2000 sows, can support with its wastes a biogas plant of 500 KW production capacity, or about 4.200.000 Kwh / year. We should consider the creation of producer groups (pig, cattle, poultry, sheep and goat farmers) that could establish joint ventures, to produce electricity and provide thermal energy.

2b) The emitted thermal energy, corresponding to 60% of the energy produced, can be used to heat either greenhouses or dryers according to local needs.

3) Composting of wastes for the production of organic fertilizers - soil enhancers.

REFERENCES

AHDB Pork. 2014 pig cost of production in selected countries. ISBN: 978-1-904437-96-3

Black JL, Giles LR, Wynn, PC, Knowles AG, Kerr CA, Jones MR, Strom AD, Gallagher NL, Eamens GJ. Factors limiting the performance of growing pigs in commercial environments, in: Proceedings of the Eighth Biennial Conference of the Australasian Pig Science Association (APSA), November, 2001, Adelaide Werribee, Victoria, pp. 150–170.

In K. Han, J. H. Lee, J. H. Kim, Y. G. Kim, J. D. Kim & I. K. Paik (2000). Application of Phase Feeding in Swine Production, Journal of Applied Animal Research, 17:1, 27-56, DOI: 10.1080/09712119.2000.9706290

Interpig report 2014. http://www.sipconsultors.com/en/home.

Kitsopanidis, G., (1980), Economics and Productivity of the Pig Industry-TechnicoeconomicalAnalysis, Thessaloniki, Laboratoryof Agricultural Economic Research, AUTH

Kitsopanidis, G., (1999), Sustainability and competitiveness of modern pig farms.AnimalScienceReview, Issue 2, p.33-51.

Batzios, Ch., (2001), Animal Production Economics, Thessaloniki. Publisher: Modern Education.

The health of the intestinal epithelium as an important factor of pig's health and the new technologies for its management

Ioannis Skoufos,
Professor, D.V.M., M.Sc., Ph.D.
Laboratory of Animal Health and Swine Production Dean of the Faculty of Agriculture Technology, Food Technology and Nutrition Division of Animal Production Technological Educational Institution (T.E.I.) of Epirus

After 60 years of continuous use of antibiotics in pig farming, the resistance of bacteria is an issue that cannot be ignored. The way antibiotics work in relation to the improvement of pigs zootechnical parameters (average daily gain, feed conversion ratio) is not totally known. Nevertheless, the fact that we are familiar with the intestinal bacterial flora and bacteria communities, as well as with the influence of antibiotics on them, could provide us knowledge about the use of alternative approaches regarding intestinal health. Many studies have shown modifications in bacterial populations after the use of antibiotics in the feed, which includes number of species, populations' size and functional defects. Moreover, the genes resistant to antibiotics increased in intestinal bacterial population after they were exposed to feed antibiotics.

The eventual transport of resistance genes from animal bacterial populations to similar or different bacterial populations in human, leads almost all countries of the world to the development of research, in order to find alternative approaches, especially for non therapeutic use of antibiotics in the feed, that is prohibited in the EU countries since from 2006.

Although the use of antibiotics in the feed resulted in an improvement on performance of more than 20% in comparison to the genetic improvement (50% from 1970-2015), made scientists and producers to neglect other factors, such as qualitative nutrition, optimum zootechnical management and pigs' welfare and finally farm environment.

The actual belief about the use of antibiotics in the feed of pigs is that the antibiotics have an impact in the total bacterial flora and on the microbiota. However, until recently, their influence on the microbiota was not easy to measure, because pig's intestinal system houses a variety of micro-organisms that are under specific environmental and nutritional conditions. It is well known that the number of bacterial populations in the body of a pig, exceed the amount of 1013, while the normal cells reach the amount of 1012. The same stands for the bacterial genes that exceed the cellular genes by 100 times.

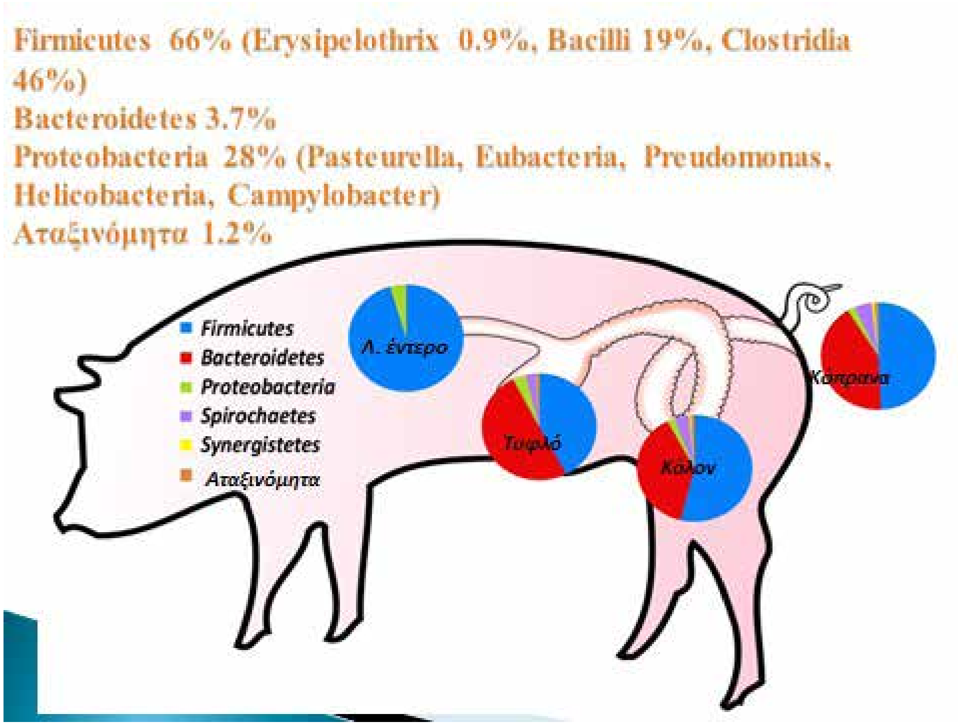
Bacterial resistance:

1993: First veterinary fluoroquinolone
1995: Enterococci resistant to vancomycin
1996: Resistance of B. Hyo to tiamulin
1996: Mutli –resistance to tuberculosis
1997: Resistance of Str. Pneumoniae to penicillin
1997: Third generation of cephalosporin to animals, celtiofur
1999: Second pleuromutilin to the animals, valnemulin
2003: New generation of antibiotics (lipopeptides), Daptomycin
2006: MRSA in pigs
2007: First human pleuromutilin, Ratapamulin
2012: New microlide for pigs, tildipirosin
2015: First case of multi-resistance in human

Brief history of antibiotics use in pigs

Additionally, the interactions between the microbiota and the host, have extremely positive effects to the animal's health, protect its metabolism function by supporting the extraction of the nutrients from the feed, develop the animal's immune system so to face eventual microbial dangers, develop the intestinal epithelium and consists a normal defense mechanism against pathogens. The production of microbial degradation products in the gastrointestinal track, provides pigs with nutritional ingredients and energy, such as vitamins, volatile fatty acids, growth factors and promotes symbiotic bacteria. Experiments conducted to germ-free pigs, have shown that the expression of the animal's genes is affected, especially of those related to the maturation of the intestinal mucosa, the absorption of nutritional elements and angiogenesis, while they require 30% more calories compared to conventional pigs so they can maintain their body weight, mainly because the germ-free pigs do not have bacterial groups that can help in the extraction of the feed nutrients in the digestive track.

The interaction of bacterial populations and intestinal mucosa is mostly beneficial except for few cases, as in humans (Crohn disease and ulcerative colitis), while changes in the bacterial populations end up to the irritable bowel syndrome.



Variability of bacteria populations in the digestive system of pigs

The intestinal mucosa is made of various and different specialized cells. The enterocytes are absorbent cells, are in the villi and they have micro villi themselves, to increase the surface of the digestion. Paneth cells are found deep in the crypts and they excrete the main antibacterial peptides produced in the small intestine. These peptides are excreted only in presence of bacteria flora and include alpha-defensin, lysozyme and the regulatory factor IIIy. Moreover, bacteria that live in the mucosa, maintain the O2 in a level that is not favorable for the growth mainly of the obligatory anaerobic pathogens, while the columnar epithelial cells (goblet cells) create a thick layer of mucosa that prevents the contact and penetration of pathogens in the intestinal mucosa. Additionally, the immune system is very important for the maintenance of balance between the host and the microbiome. The Payer plates and the cylinder lymphatic follicles are covered by specialized epithelial cells called M-cells that “catch” first the antigens directly from the intestinal track and they present them to T-lymphocytes, helping the immediate production of B cells (antibodies) and memory cells. Without the presence of bacteria populations, the lymphocytes cannot grow and the B cells cannot mature from T cells through factor Th 17, nor can its production be controlled through regulatory T cells. As a result, each pig is vulnerable to any disease.

Consequently, without the special metabolic functions of bacteria and the final products of fermentation, pigs cannot be healthy nor optimize their performance by taking full advantage of their genetic material.

The epithelium of the large intestine depends exclusively from the nutritional products of the fermentation process effected by the bacteria existing in it and producing energy.

Therefore, the question is how the metabolic functions of pigs' digestive system can be maintained with the maximum presence of beneficial bacteria, but without the use of antibiotics in the animal feed, given that their presence in the ratio has a negative influence on the intestine bacterial flora. At the same time, public opinion, consumers express their strong concern about the increasing microbe-resistance that becomes even multi-resistance, by pushing their governments to study carefully the issue of health management, especially for swine and birds, since there is a big number of resistance genes which is detected in the το microbiome of monogastric animals. Even if antibiotics are not used, in case of organic farming, a big number of resistance genes is detected in tetracyclines encoding plasmids. When the resistance is in the plasmids, then it spreads rapidly, even between bacteria and pathogens that are not related, while other scientific researches show that only the presence of antibiotics in the feed facilitates the transport of resistant genes via the lysis of bacteriophages.

Staphylococcus aureus resistant to Methicillin, has been detected in pigs in the 70's. Today it is not considered as an animal pathogen, but it is a significant problem for human's health.

Are there alternative solutions for minimizing the use of antibiotics in pigs feed, without put in danger the digestive system health? It is obvious that lesser diseases mean lesser use of antibiotics. However, the question does not concern the use of antibiotics in sick but in healthy animals. Are there viable solutions for the zootechnical performance to be kept and even improved, without the use of antibiotics in feed, something that is happening already in the EU, but by having a control over the level of the animal's infection?

The characteristics of this system must definitely include changes in the animals' nutrition, the micro-environment of the livestock farm, the bio safety systems and the preventive health management via vaccinations and then a system of specific interventions by using active substances/additives, that affect positively the digestive system and the metabolism of the animal and bring significant improvement to swine health.

Technologies based on holistic management of pig's health without the use of antibiotics

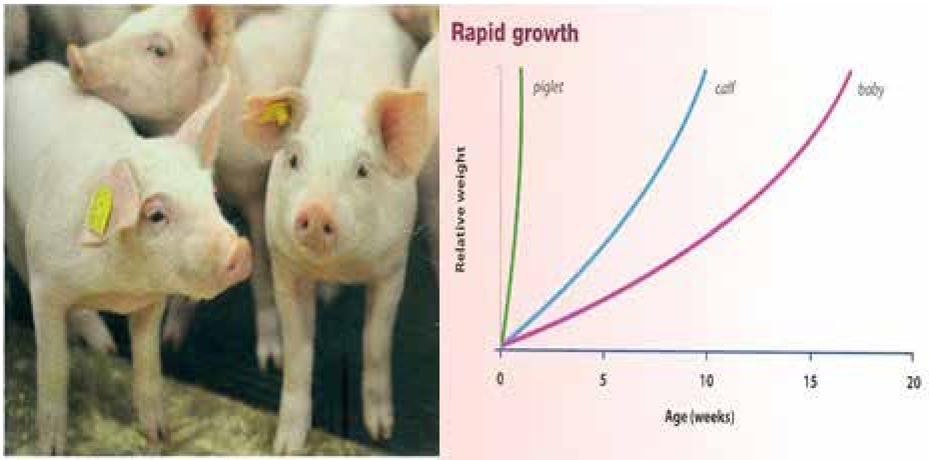
Energy and protein sources	Alternative supplements	Standard Health Management
Blood plasma	Hyperimmune eggs	Biofilters
Milk protein	Oligosaccharides	Biosafety
Conventional egg products	Probiotics	Vaccination program
Lactose	Prebiotics	Disinfection
	Phytogenics / essential oils	Farm microenvironment
	Organic acids	Resistant breeds in specific diseases
	Dietary fibers	Model farms with automated measuring systems
	Yeast, yeast products	
	Bacteriocins	
	Enzymes	
	Clay minerals	
	Butyric acid	
	Middle / Short chain fatty acids	

It is well known that the genetic potential of the pig allows today to reach 10 Kg L.W. in 28 days, 45 Kg in 75 days and 100 Kg in 130 days, if fed solely on milk products. The use of porcine plasma products (spray - dried plasma) has proven to improve growth rate by 30%, and possibly due to the immunoglobulins contained in plasma provides protection against intestinal and other diseases. Alternatively, the use of hyperimmune eggs, from hens immunized for specific pig pathogens and produce antibodies against them, constitutes a contemporary way to address the absence of antibiotics in feed and their nutritional use brings passive immunity against specific diseases. It is a fact that the expression of clinical disease is dramatically reduced and yields are greatly increased with the use of dehydrated porcine plasma or hyperimmune eggs. The use of lactose, which is an easily digestive carbohydrate is a key factor for the feeding of pigs, but can also act as a prebiotic, i.e. a nutrient medium for the growth of beneficial bacteria, while stimulates the production of lactobacilli in the stomach resulting in the production of lactic acid that simulates the action of the incorporation of an organic acid in the feed.

Health of the gut: Back to basics

Nutrition

Development : 30th day 15kg, ADG 600g
30th day 10kg, ADG 400g
50th day 32kg, ADG 700g
50th day 19kg ADG 500g



Potential of pig growth

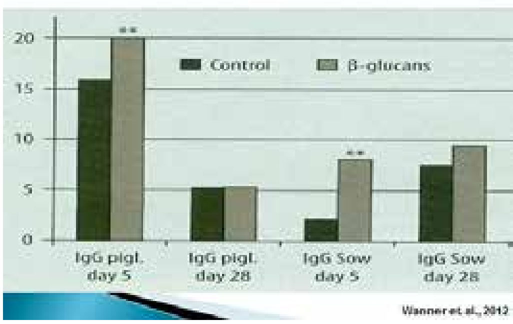
Regarding alternative supplements, mannose and fructose oligosaccharides predominate, constituting complex compounds of the outer layer of the cell wall of yeast. It is considered that they a competitive act on the receptors binding pathogenic bacteria, in order not to adhere to the intestinal mucosa. Technologies where prebiotic must survive the digestive process are important to let it act effectively.

Probiotics and prebiotics. Probiotics are vital or sporogenous bacteria added to pig feed as an alternative strategy to strengthen the microbial flora of the gut. Food production in the form of pellets (pellets) reduces the effectiveness of their use, especially for lactobacilli or bifidobacteria species, but microencapsulation techniques may make them more resistant. In any case, the strains used should be acid-fast. Alternatively, instead of adding in the feed beneficial bacteria, we can use substrates for the growth of beneficial bacteria and we come back to the use of prebiotics which are again mannan-oligosaccharides, trans galacto-oligosaccharides and fructo-oligosaccharides. These are the end products of non-digestible fermented sugars which favor the development of lactobacilli, but in feed, besides the final products mentioned before, raw materials can be used such as, sugar beet, apple and horseradish pulp. that contain also large quantities of inulin - dietary fibers.

Technologies for the protection of the organic acids and essential oils and ideal release in the digestive system

Dietary fibers consist mainly of non-starch polysaccharides, i.e. carbohydrates which are not digested by the digestive enzymes of the pig. Thus, because they avoid digestion in the small intestine, remain available for microbial fermentation in the colon, resulting in energy production while supporting and maintaining the fermentative bacteria. They stimulate the secretion of hydrochloric acid in the stomach, creating a highly acidic environment that prevents the growth of pathogenic bacteria. Their administration is not recommended in nursing piglets, as they are already receiving lactose resulting in the production of lactic acid which stimulates the action of hydrochloric acid. Inulin and oligofructose stimulate the growth of bifidobacteria and lactobacilli resulting in the production of volatile fatty acids which contribute to the barrier of pH acidity. Volatile fatty acids such as acetic and propionic acid are active against pathogens. Also, butyric acid plays a key role in the regeneration of damaged epithelial tissue, a known problem of weaned piglets mainly due to the changes in the composition of feed, bacterial toxins and feed allergies.

INFLUENCE OF PREBIOTICS IN IMMUNOSTIMULATION



ΠΡΟΣΘΗΚΗ ΠΡΕΒΙΟΤΙΚΩΝ ΙΝΩΝ ΚΑΙ ΕΠΙΔΡΑΣΗ ΤΟΥΣ ΣΤΗ ΜΙΚΡΟΒΙΑΚΗ ΧΛΩΡΙΔΑ

Location/Bacteria	Control	Oligofructose
Ειλεός		
Total Coliform	-	-
Lactobacilli	7,4	7,77
Bifidobacteria	6,4[b]	8,87[a]
Κόλον		
Total Coliform	7,18[a]	6,30[b]
Lactobacilli	8,71	7,79
Bifidobacteria	6,71[b]	6,83[b]

At the same time, they increase calcium absorption, regulate gut motility and reduce the emission of ammonia, as the reduction in pH alter the microbial metabolism from proteins, to carbohydrates, creating a better microenvironment for sustainable pig production systems.

Short chain fatty acids produced spontaneously by the pig when dietary fiber and non-digestive forms of sugars are fermented in the large intestine by the microbiome. The most frequent and important fatty acid is butyrate as it is the preferred metabolite of colonocytes. The absorption mechanism by the epithelial cells of bacteria creates a source of ATP which delivers energy activating the sodium pump maintaining osmotic balance in the intestine allowing water to be reabsorbed in the large intestine and the relatively watery wastes to become more solid faeces. The mechanism is based on consumption of O2 and the lack of it is making the lining of the colon hypoxic, resulting in anaerobic conditions that favor the growth of clostridia necessary for the production of endogenous butyric acid. In other words, a self-supply mechanism is created in the large intestine.

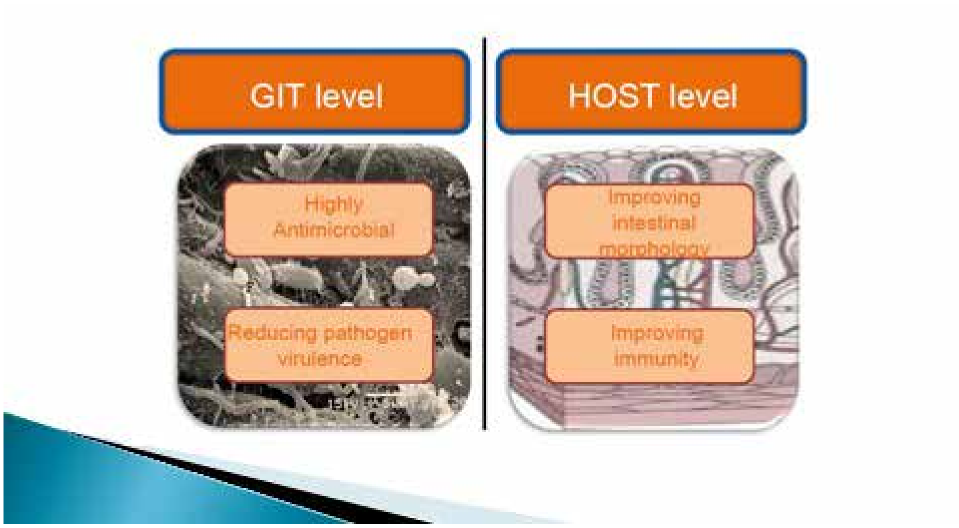
ΠΟΣΟΣΤΑ ΟΡΟΘΕΤΙΚΟΤΗΤΑΣ ΣΤΟΝ ΚΥΚΛΟΪΟ ΜΕΤΑ ΤΗ ΧΡΗΣΗ ΚΥΤΤΑΡΙΚΩΝ ΤΟΙΧΩΜΑΤΩΝ ΖΥΜΩΝ, Wu et al., 2008

Εκτροφές	Προ χορήγησης	Μετά χορήγησης	Ποσότητα προσθετικών (kg/t)
Farm A	88.24	33.30	2
Farm B	15.79	11.43	2
Farm C (breeding pigs)	60.00	30.80	2
Farm D (piglets)	28.60	0	2
Farm E	71.43	32.00	1.5-2

Percentage of positive infected in circovirus after the use of yeast cell walls.

The gut is the largest immunologically active organ. Short-chain fatty acids have an important role in homeostasis of the gut, but act also as a vital link between the porcine microbiome and the host's immunity. They affect the gene expression, proliferation and apoptosis of the intestinal epithelial cells. Butyrate increases the proliferation of enterocytes in the crypts, while increasing apoptosis of epithelial surface cells balancing cellular changes in the gut level. Mobilizes antimicrobial peptides, neutrophils, while regulating the presence of dendritic cells and macrophages mainly present by bacterial antigens to T lymphocytes. Protected forms of butyric acid gives the possibility to overcome the problem of gastric acidity, while esterified forms such as tributyrin have shown to be more active.

MCFA – MODE OF ACTIONS



As the butyric acid found in the milk of the sow in a complex form with a glucose molecule, so do the new forms of administration that have strong ties respective to triglycerol which are degraded only by enzymes, such as lipase. Thus the form of tributyrin crosses the barrier of the stomach and under the influence of pancreatic lipase release butyric acid in the intestine yielding 200% more acid than the protected forms of the salts.

In addition to the short chain fatty acids, medium chain fatty acids exhibit beneficial effects on pig health and performance. The A-monolaurin is a molecule produced by the esterification of lauric acid and glycerol, detached of the pH action, absorbed by the lymph and the circulatory system. The strong antibacterial property, particularly on Gram + bacteria, is known in the literature, especially against Streptococci and with antiviral properties especially against arteriviruses (PRRS). Monoglycerides exhibit very strong antibacterial properties against free fatty acids and their use constitutes an alternative agent for production of the new generation models with antiviral and antibacterial activities promoting animal health and their performance in the absence of the use of chemotherapeutic.

The benefits from photogenic feed additives have been extensively described in the literature, however is a fact that many of the properties of the essential oils, while they have been extensively studied in vitro they have not been identified completely in vivo, but their activity also shows large variations depending on the secondary metabolites of the plant species with those depending on the botanical composition of the plant from which the additive has come.

The photogenic supplements are herbal ingredients such as herbs, essential oils or aromatic plants and are used for many years for medical reasons.

The photogenic components can be extracted from different plant parts and composed of almost all organs of the plant (stems, roots, flowers, bulbs, nuts).

Essential oils are a small part of the plant composition. They have however certain characteristics which are used in the food industry and pharmacology. Their action as additives in animal nutrition appears as anti-inflammatory, buffering the microbiome of the bowel, stimulation of the digestion and the action of bile and digestive enzymes, increase of amino acid uptake, having antidiarrheal activity, facilitating the attraction of feed for pigs due to their aromatic properties, improve animal technical indicators even the composition of the carcass (increased percentage of meat).

The main essential oils used in animal production derived from rosemary, thyme, oregano, sage, pepper, bay leaf, and garlic, wherein the respective essential oils exhibit bacteriostatic or bactericidal effect on specific microbes, mainly E. coli, Salmonella spp, Staphylococcus spp, Listeria spp and Campylobacter spp.

Essential Oils
Antibacterial action in vitro

+

Κατάταξη	Χημική ομάδα	Συστατικό	Αιθέριο έλαιο
1	Phenols	Thymol, eugenol, carvacrol, gaiacol	Thyme, oregano, clove, cinnamon leaves, ...
2	Aldehyde	cinnamaldehyde	Inner bark of cinnamon tree
3	Monoterpénol C10	1-terpinène-4-ol	Tea tree
4	Aldehydes	Geranial, citronellal	Lemon grass
5	Cetones	Verbenone, menthone, carvone	Rosemary, aniseed, mint
6	Ether	Estragol, anethol	Basil, aniseed, star anise
7	Oxydes	Eucalyptol	Eucalyptus
8	Terpenes	Pinenes	Pines, firs

-

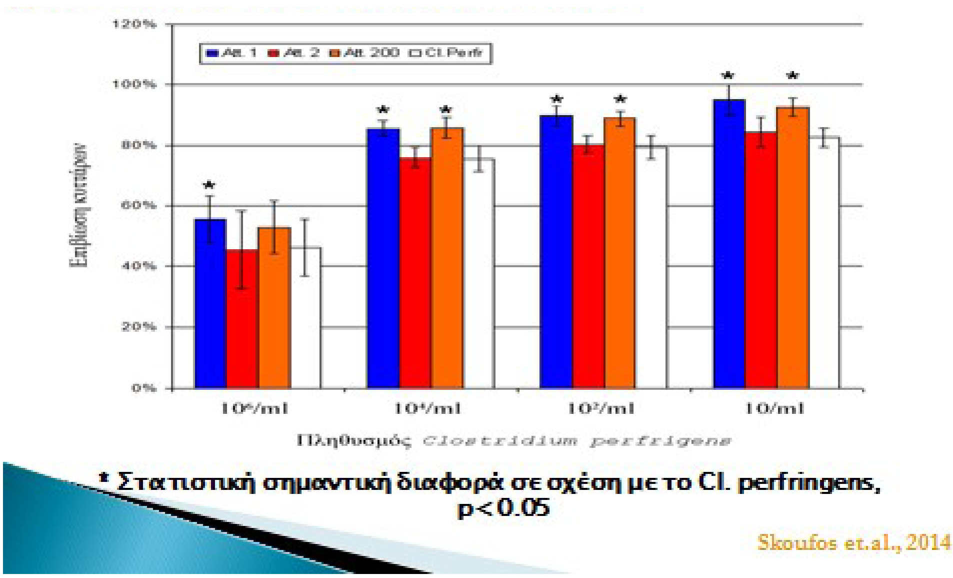
Knobloch et al., 1989; Franchomme et al., 1990; Dogna, 1990; Inouye et al., 2001; Friedman et al., 2002; Hernandez-Ochoa, 2005

Finally, a new category for pig nutrition which combines mainly, essential oils -that can affect the bacterial cell, organic acids that can penetrate in the bacterium and affect its functions, and a mixture of fatty acids of small and medium chain that have also antibacterial properties, can lead in a more balanced microbiome, emulating in a degree the mode of action of an antibiotic. The presence of enzymes and probiotics is another way of synergy for the upkeep of the integrity of the mucosa and its effectiveness in zootechnical - production parameters.

Enzymes are widely used in pig nutrition mostly for the disintegration of anti-nutritional factors that hail from raw materials of the ratio (non-starch polysaccha-

rides in cereals) and to decrease the undigested percentage of proteins, fat and carbohydrates, which can be the perfect medium for the growth of bacterial population. Although, the use of proteolytic enzymes is an expensive solution for the improvement of proteins digestibility, their usage is decreasing the viscosity of the intestinal track and prevent the reproduction of pathogen bacteria because of the good mobility of the feed inside the intestinal track.
Also the use of clay minerals such as kaolinite, montmorillonite and attapulgite, alongside with essential oils and seaweed extracts, increase the activity of the peptic enzymes (higher pancreatic lipase and protease), while they have anti-diarrheal properties and adsorptive act against toxins especially of mycotoxins.

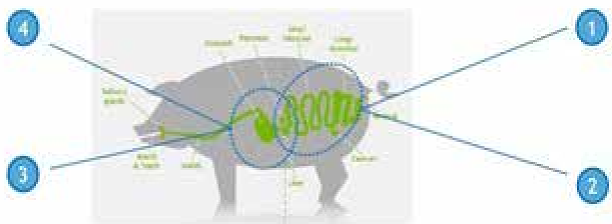
Effect of mineral clay/ essential oils / MCFA/ boutyric acid in enterocytes of the pig with the presence of Cl. perfringens



It is also known, that we can use nutritional supplements in alternative ways to affect the microflora of the stomach, of the small and the large intestine. This can be achieved with the strategic grant of medium chain fatty acids for the stomach and the small intestine, small chain fatty acids for stomach and the oral cavity, organic acids for the oral cavity for the stomach and the small intestine, enzymes for the stomach and the small intestine and a mixture of essential oils and phytogenic ingredients for the small and the large intestine.
Their action in synergy can contribute in their absorption from the cellular membrane of pathogenic bacteria which results in the increase of its penetrability in order that their content leak to the extracellular fluid (ECF). On the contrary, organic acids or other phytogenic components can infiltrate in the bacillary cell and intervene in its operations.

Mixtures of additives based on essential oils, prebiotics, and fatty acids can demonstrate antibacterial action not only for gram negative, but also for gram positive bacteria.

SYNERGETIC ACTION



	1	2	3	4
Who?	coated buturic acid	coated propionic acid	essential oils	MCFA
Where?	entire gut	entire gut	crop, stomach proximal gut	crop, stomach proximal gut
What?	gut empowerment	bacteriostatic	bacteriostatic (Gram -) pancreatic enzyme secretion	bacteriostatic (Gram +)

The advantages of micro-encapsulation of organic acids, fatty acids and phoytobiotics, are exceptional, since it prevents the effect of unfavorable environmental factors in their formation (mainly in acidity), increases their bioavailability and their activity along the digestive system, improve their absorption and their stability and demonstrates their advantages. At the same time can partly cover their unpleasant or intense smell that are repellent for the animals.

The digestive system is the key implement for the health both of the men and the animals. It is so important that it is also called “the second brain”. To raise pigs can be compared to an airplane flight. It is very safe but a human mistake can lead to total devastation.

The intestinal track and its complementary organs include more cells than the rest organs of the pig. Furthermore, they direct the metabolism and the immunological maturing of the animal.

Today it is widely known that the health of the pig depends on three basic components of the nutrition triangle: The diet, the intestinal mucosa and the microbiome. The kinds of microbes that can be found in the intestinal mucosa are only known in a percentage of 10% since only the lactobacillus and the bifdobacteria can be cultivated.

The pig nutrition is a modern miracle and can guide the peoples’ nutrition. Diarrheic syndromes, constipation, tolerance in lactose, ulcerous colitis, diabetes etc. The usage of probiotics and prebiotics is the number one issue for human nutrition. The fermented foods, polyunsaturated fatty acids, chelated trace ele-

ments, microbiome, wherein particularly the use of enzymes increases eubacterial populations (E. hallii and E. limosum) stimulating the immune system and reducing the number of clostridia in the small intestine.
Many questions remain unanswered. Will the antibiotics be used in the future? How the new technologies (nutrigenomics, omics, transcriptomics, genomics) will guide us to the future strategies of pig health management?
Which is the perfect microbiome for the pig? Does it depend on the breed? Will be resilient breeds at viral and bacterial diseases? Is there a limit in the development of the pig and its reproductive ability?
In the year 2025 a sow will produce 5TN of meat? How this will affect the health of the animal? Where the animal origin proteins will be found? And how will be replaced in the ratios?
The overall approach is not simple. Furthermore, there is not one universal management strategy. Every farm is an individual organization. A combination of practices can offer better alternatives for every individual system and can lead the massive production of pork meat in more specialized models.
In these models, the alternative forms of administration of nutritional supplements which assist the pig health and prevent the widespread use of antibiotics will proliferate defining also consumers' behavior to techniques and technologies evolving, at least in developed countries.
Let us not forget. Pork is the other white meat after chicken and is the beloved meat of consumers. The new technologies for the health management of the intestinal epithelium are exactly facing the visibility and safety of pork and pork end products.

Application of alternative nutrition supplements in pigs ratio to replace antibiotics

Χοιροστάσιο	Επίπεδο υγείας			
Επίπεδο διαχείρισης	Άριστη	Καλή	Μέτρια	Κακή
Άριστο		OA	OA+EE	OA+EE+OG
Καλό	OA	OA+EE	OA+EE+OG	OA+EE+OG
Μέτριο	OA+EE	OA+EE+OG	OA+EE+OG	Χρήση αντιβιοτικών
Κακό	OA+EE+OG	OA+EE+OG	Χρήση αντιβιοτικών	Χρήση αντιβιοτικών

OA = Οργανικά οξέα, Προβιοτικά EE = Αιθέρια έλαια, OG = πρεβιοτικά, OG Ορυκτές γαίες

Τροποποιημένο M. Varley, 2012

MULIVET®

dynamic treatment