

**Abstracts of the “12^e JOURNÉES DE LA RECHERCHE CUNICOLE”
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The Journées de la Recherche Cunicole have been organized since 1973 by the INRA (Institut National de la Recherche Agronomique) and the ITAVI (Institut Technique de l'Aviculture), with the participation of the ASFC (Association Scientifique Française de Cuniculture). The 12th edition was held in Le Mans (France), 27-28 November 2007. A total of 51 communications (including 2 reviews) were presented in 8 working sessions. - Behaviour, dealing mainly with the relations between dam and offsprings - Reproduction, dealing mainly with biotechnologies and male physiology - Nutrition and digestive physiology with a review about the caecal ecosystem - Genetics, with a focus on new selection methods - Economy, with a review on sustainability of rabbit production - Meat quality, dealing mainly with the nutritional quality of rabbit meat - Pathology, including a session dedicated to the ERE.

**BEHAVIOUR: DAM-PROGENY
RELATIONS****THE BEHAVIOURAL RESPONSE OF
YOUNG RABBITS TO THE MAMMARY
PHEROMONE: REGULATIONS AND
POTENTIAL IMPACT OF DOMESTICATION**

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Newborn rabbits localize and seize the maternal nipples in following odour cues emitted by lactating females. The mammary pheromone (MP) carried in rabbit milk is one of these cues: at birth, it releases the typical searching-oral grasping behaviour allowing to suck in more than 90% of pups. Then, the responsiveness remains high until day 10, before the daily sucking. However, recent results suggest that the responsiveness becomes progressively regulated between birth and weaning by two kinds of mechanisms: physiological factors associated with satiation, and factors associated to changes in the sensory capacities of pups and in the mother-young relationships. Moreover, these regulations appear to develop differently in laboratory housing conditions and in semi-natural conditions. Here, we propose a review of these different results.

**THE RESPONSIVENESS OF YOUNG
RABBITS TO THE MAMMARY
PHEROMONE: A PREDICTOR OF
SURVIVAL?**

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The present study aimed to explore the link existing between the responsiveness/unresponsiveness of rabbit pups to the mammary pheromone, the early weight of pups, and their milk intake, growth and survival. To that goal, 293 newborns from 30 litters were tested for their responsiveness to the mammary pheromone and for their milk intake on postnatal day 1, and their mortality and growth were checked until day 21. About 90% of the pups responded to the mammary pheromone on day 1. Pups who were unresponsive to the mammary pheromone were less successful in gaining milk and had a higher rate of mortality than the responsive pups during the three first postnatal week ($P < 0.05$). This impact was modulated by the weight of pups: it appeared in the lightest newborns tested on day 1 (<48 g, in our study). Moreover, the present study confirmed the positive impact of the day 1-pup weight and sucking success on the pup viability and growth during the three first postnatal weeks ($P < 0.001$). To conclude, the non response to the mammary pheromone on day 1, in our single behavioural test, appears as one of several factors influencing the viability of young rabbits in breeding units, and should be used to identify and isolate newborns presenting high risk of mortality among the lightest pups.

**LEARNING PLASTICITY OF NEST
OLFACTORY CUES IN THE NEWBORN
RABBIT**

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Newborn rabbits are able to discriminate between the olfactory cues from their nest and those from a nest built

by another doe. We hypothesized that this preferential response reflected postnatal learning processes. To test this and to determine the dynamic of learning, we transferred part of the litter to an alien nest. The results showed that postnatal learning of the new nest was possible on the 2nd day after birth with a maximum response 24 h after the start of the adoption procedure. Learning the characteristics of the new nest induced a lack of interest for the original nest which is not a total amnesia since a recall of the original nest can reinstate a preference for it. This experiment illustrates the plasticity of early olfactory learning in newborn rabbit.

NASAL DIFFUSION TO RABBIT: ANALYSIS OF THE DIFFUSION QUALITY OF A NEW DEVICE

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We studied a new device for the delivery of actives for nasal application. Active ingredients are incorporated in aqueous gel which desegregates with air and then diffuses the actives. The subject of this study is to measure the quality of the diffusion of the gel placed in different conditions of temperature and humidity. The gels are weighed at the beginning of the study and during the diffusion study to evaluate the impact of the different environmental parameters on the delivery of the actives in the air. We demonstrated that when temperature is close to 25°C, more the air is wet more the diffusion is slow. When the temperature increased, then the diffusion duration increased also. A bloc gel is a reliable device to diffuse actives in the atmosphere for nasal application.

EVOLUTION OF THE CHEMICAL COMPOSITION OF THE MILK OF A STOCK OF LABORATORY RABBITS DURING LACTATION

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Seven does of rabbit stock of laboratory Charles River 052 NZW were milked each morning, while nursing their young rabbits, starting from 4th and until the 28th day of lactation using a milking machine whose principle is based on the vacuum pump. The analysis of the chemical composition of milk shows a variability of the parameters according to the stage of lactation. The composition in lipids, proteins or dry matter of milk, strong with the starting of lactation, decrease until the third week. We note an increase in the concentration of these elements during the 4th week. The lactose, quantitatively not very important, has a content which falls after the peak of lactation to become very low at

the end of the lactation on certain females. The content of mineral matters constantly increases beginning at the end of lactation. These data make it possible to have a referent for the study of the diarrhoeas of no microbial origin of the not weaned young rabbits but also to understand how to better nurse the young rabbits artificially on the basis of the cow's milk.

EFFECT OF THE SPACE ALLOWANCE AND ENRICHMENT ON THE YOUNG-MOTHER INTERACTIONS IN RABBIT

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This study was carried out to measure the effect on the young-mother interaction of the space allowance (3400 vs 4500 cm²) and the presence or not of a platform in rabbit does' cages. The frequencies of nursing and suckling-attempt (per 24h00) decrease between the third and the fifth week post partum ($P < 0.05$). Increasing space allowance in the third week post partum lead to reduced nursing frequency ($P < 0.05$) Otherwise, the space allowance and the enrichment have no major effect on the variables measured. The descriptive study of the kinetics of nursing and suckling attempt, which both follow a circadian rhythm, suggest a feed-back relation between the two behaviours.

REPRODUCTION

CRYOPRESERVED OVARIAN TISSUE AUTOGRAFT: ASSESSMENT AND FURTHER PERSPECTIVES

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Ovarian tissue freezing allows preserving simultaneously thousands of immature follicles of the ovarian stock. This follicles need to define a technique to restore folliculogenesis and to obtain mature follicles. The objective of this study was to define a technique of orthotopic autograft allowing the restoration of the follicular growth after slow freezing of the ovarian tissue, and to validate the freezing protocol. Eight doe rabbits were ovariectomized, 16 received a fresh ovarian tissue bilateral graft and 16 received a frozen ovarian tissue unilateral graft. Inseminations were performed during the next 10 successive cycles. No pregnancy was obtained in ovariectomized group, 15 and 9 pups were born after fresh and frozen/thawed ovarian tissue graft respectively.

RABBIT PRODUCED BY INTRACYTOPLASMIC SPERM INJECTION (ICSI), WITH SPERM PRESERVED AT ROOM TEMPERATURE

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We propose a new technique of rabbit production, in the rabbit species, based on the direct injection of sperm into mature oocytes. This technique, ICSI (intracytoplasmic sperm injection), is already used in human medicine. We show that ICSI with ejaculated sperm preserved at room temperature during 24 hours and with a desynchronized preparation of recipients, results in the birth of viable pups. These preliminary results indicate that the efficiency of ICSI in the rabbit species expressed in term of number of viable offsprings per transferred embryos is higher than 20%.

INFLUENCE OF THE INTERVAL BETWEEN WEANING AND THE BEGINNING OF A SUPEROVULATION TREATMENT, ON RABBIT EMBRYO PRODUCTION AND THEIR QUALITY

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This experiment aimed at studying if the interval between weaning and the beginning of a superovulation treatment influences the rabbit embryo production and their quality. Twenty rabbit does of a commercial strain (AGP22, Grimaud Frères) coming from 3 generations of a divergent selection experiment on within litter homogeneity of birth weight were used. At weaning of the 4th litter, 10 does of the heterogeneous line and 10 does of the homogeneous line are injected to induce superovulation (5 successive injections in a 12 hours interval). Twelve hours after the last injection, rabbit does were inseminated. Does of both lines were distributed in 2 experimental groups: beginning of the treatment of superovulation the day of weaning (group 0) or 5 days after weaning (group 5). From 65 to 72 hours after insemination, the ovaries are observed and the genital tracts are flushed. The line clearly does not influence the response to the treatment of superovulation. However, when the 1st injection is carried out the day of the weaning of young rabbits, the ovarian response is higher (35.0 vs 24.4 corpora lutea, $P=0.058$). The number of embryos of quality varies little (15.7 and 12.4, respectively for groups 0 and 5), however the number of fertilized but degenerated embryos, is significantly weaker (5.9 vs 1.5, $P=0.044$). This preliminary study thus shows that the physiological stage of rabbit does around weaning influences the response to a treatment

of superovulation as well as the production of embryos of quality.

OPTIMIZATION ATTEMPTS OF THE EMBRYOS PRODUCTION IN THE RABBIT DOE

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Given the variable efficiency of the superovulation treatments applied to embryos freezing, this frequently used technique involves an irregular embryos production. That work aims to optimize the qualitative and quantitative production of embryos in rabbit species through the study of LH effect in treatments of superovulation (experiment 1) or trying to synchronize follicular waves (experiment 2). LH effect was evaluated by the comparison of two superovulation treatments using porcine FSH and containing or not 20% of porcine LH. Synchronization treatment used, before the same superovulation treatment (+20% LH), prostaglandins $F_{2\alpha}$ on induced pseudopregnant does. Despite an increased regularity of responses, these studies failed to improve significantly the embryos production results compared to the classical treatment. Once more, this study highlights the lack of scientific knowledge on the kinetic of follicular waves establishment in rabbit species.

EVALUATION OF THE REPRODUCTIVE PERFORMANCES OF A LOCAL RABBIT POPULATION IN ALGERIA

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The reproductive performances of the does livestock at the experimental farm of the Institut Technique des Elevages, located at Baba Ali (Alger's), from a local population, was studied. The rate of receptivity, fertility, delivery and weaning were respectively 89, 87, 78 and 56%, but the average number of litters per year and per female rabbit was only of 3.6. The prolificacy rose to 7.1 young born, 5.6 born alive and 3.0 weaned per litter. The weight of the litter at birth and at weaning was respectively 276 and 3332 g; the individual average weight at weaning was 579 g. The season affects female's receptivity, which decreased significantly in summer and autumn. The average weaning weight of young rabbits in winter and spring was the higher. The prolificacy of the does and the weaning weight of the young rabbits needs to be improved.

POST-NATAL SEXUAL DEVELOPMENT IN THE RABBIT: GROWTH AND MATURITY PATTERNS OF TESTIS AND EPIDIDYMIS IN TWO LINES

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The present work was performed in two lines of rabbit of different reproductive aptitude to assess the effect of the line on age related changes of reproductive parameters. Caldes and Prat lines showed similar developmental profiles for most of the variables studied, which showed major changes at young ages. The percentages of seminiferous tubules with lumen (STL) and with presence of spermatozoa (STS) at 20 weeks of age were low in both lines (about 70% and 40%, respectively). Caldes line had higher live weight (LW) and lower testis volume (TV) than Prat line at any age. No differences between lines were found for microscopical variables of testes, except for STL. Line Prat showed higher values of STL at 14 weeks but lower at 33 weeks, suggesting that lines could have a different sexual development pattern.

DOES SELECTION FOR GROWTH RATE INFLUENCE THE FERTILISING ABILITY OF RABBIT SEMEN?

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To study the effect of selection for growth rate (63-d body weight) on the fertilising ability of rabbit semen, 17 bucks of two divergent lines for growth rate were used. 101 rabbit does of strain INRA 2666, and 124 does of strain INRA 1067, were inseminated every 42 days during 4 series. The bucks of the Low line produced semen with a higher volume (0.62 vs 0.54 ml), a higher pH (6.96 vs 6.88), a higher mass motility (6.98 vs 6.72), but a lower concentration (686 vs 771 × 10⁶ spz/ml) compared with the bucks of the High line. Fertility, prolificacy and productivity at weaning were largely influenced by the farm, the AI serie and the physiological status of the does, but they were not influenced by the bucks line. In our experimental conditions, selection for 63-d body weight does not influence the fertilising ability of rabbit semen.

NUTRITION AND DIGESTIVE PHYSIOLOGY

REVIEW: THE CAECAL ECOSYSTEM OF THE DOMESTIC RABBIT: IMPACT OF NUTRITION AND OF SOME FEEDING FACTORS - IMPLICATIONS FOR THE DIGESTIVE HEALTH OF THE YOUNG RABBIT

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The caecal ecosystem plays a key role in the digestive physiology of the rabbit, as well for its digestive health than for its digestive efficiency. This digestive ecosystem, corresponding to the association of a biotope (the caecal medium and the organ) and of a biocenosis (the caecal microflora), is very complex and its functioning remains still badly known. This review will first summarize the data concerning the caecal biotope and its physico-chemical characteristics, which were subjected to numerous studies. Our knowledge of the caecal biocenosis, obtained by the traditional culture based methods will be then presented, and then those obtained recently using the new tools of molecular microbiology. Lastly, this review will describe the effect of some main nutrients and of some feeding strategies on the function of this ecosystem, and the relationships with the digestive health of the young rabbit.

MOLECULAR INVENTORY OF MICROBIAL ECOSYSTEM IN THE RABBIT CAECUM: RESULTS AND PERSPECTIVES

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Recent advances in molecular biology tools now allow us to characterize (identified bacterial species) complex digestive ecosystems. We constructed a library based on 16S rDNA analysis from an adult rabbit caecum sample. We obtained 228 clones. The sequence analysis identified 70 OTU (operational taxonomic unit), 80% of which are considered as new bacterial species. The phylogenetic analysis of the OTU classified the vast majority of them in the *Firmicutes phyla*, and very few in *Bacteroidetes* and *Verrucomicrobiae*. There was little correspondence

between this study and a previous library constructed from young rabbits samples. Our results show how the rabbit digestive microflora was quite specific.

COMPARED CHARACTERIZATION OF BACTERIAL COMMUNITIES IN CAECAL CONTENT, SOFT AND HARD FÆCES OF ADULT RABBIT USING CE-SSCP

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The aim of this study was to characterize caecal bacterial communities using CE-SSCP and to compare them with those of hard and soft faeces in terms of dynamic and individual variability. Soft and hard faeces of 14 adult rabbits were weekly sampled during 5 weeks while caecal content were sampled on weeks 3 (surgical way) and 5 (after sacrifice). Bacterial communities were compared according to their structure (CE-SSCP profiles analysis) and diversity (modified Simpson biodiversity index). Without perturbations, caecal bacterial ecosystem remained constant but showed individual variability. On the other hand, sampling caecal content by surgical way modify bacterial diversity and structure. These results suggest the necessity to find an alternative and reliable type of sample to investigate dynamic studies of caecal bacterial communities. According to bacterial community structure, soft faeces seemed closer of caecal content than hard faeces. In contrary, diversity index of caecal content, soft and hard faeces did not differ (diversity index: 3.71 ± 0.50 , 3.85 ± 0.58 and 3.99 ± 0.51 , respectively; NS). Therefore, soft faeces could be used to investigate dynamic studies of caecal bacterial communities.

AN ORIGINAL METHOD TO MEASURE REDOX POTENTIAL IN RABBIT CAECUM: THE FIRST METHODOLOGICAL RESULTS

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The study aimed to set up a method for measuring the redox potential (Eh) in the rabbit caecum, for assessing the anaerobiosis in the caecal biotope. Eh, pH and temperature in caecal content were measured according to 2 procedures (*in vivo* vs *post mortem*) and at 3 hours in the day (8-10 h, 12-14 h, 18-19 h), on a total of 34 rabbits aged of 65 days and weighing 2.2 kg. pH, Eh were not significantly affected by the method nor by the sampling hour in the day. Mean values for pH, Eh were 6.2, -204 mV respectively.

Only the caecal temperature was 2°C higher ($P < 0.01$) for *in vivo* (39°C) compared to *post mortem* (37°C) method. The Eh was high 2 min after the start of the measurement, and then stabilised after 20 min to reach at 35 min -220 ± 20 mV. This confirmed that the rabbit caecal ecosystem was highly anaerobic.

EFFECT OF WEANING AGE, LEVEL OF DIETARY FIBRE AND ENVIRONMENTAL HYGIENE ON THE CLOSTRIDIUM PERFRINGENS QUANTIFICATION IN THE DIGESTIVE TRACT OF RABBITS AND ON THE MORTALITY

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Rabbits from eighty litters were allocated to different experimental treatments: age at weaning (28 or 42 days), level of dietary fibre (25 vs 20% of ADF) and housing hygiene conditions (disinfection or not at the beginning of the experiment). The results show that disinfection of the farm had a significant effect on the caecal concentration of *C. perfringens* 14 days after weaning and on the fattening mortality ($P < 0.0001$). A delay in weaning also improved fattening mortality and reduced caecal concentration of *C. perfringens* 14 days after weaning, but the effects were only significant in poor hygiene housing conditions. Dietary fiber content did not affect any of the traits studied.

EFFECT OF THE DIETARY SUPPLEMENTATION OF GLUTAMINE AND ARGININE ON THE INTESTINAL HEALTH, ILEAL AND CAECAL MICROBIOTA AND FATTENING PERFORMANCE IN WEANED RABBIT AFFECTED BY ERE

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The aim of this work was to study the effect of a supplementation of L-glutamine (1%) or L-glutamine+arginine (1+0.5%) on the ileal and caecal microbiota and fattening performances in rabbits weaned at 25 days. The mortality rate was high because of Epizootic Rabbit Enteropathy (ERE) and animals were supplemented from 25 to 56 days of age in every treatments (control, Glu and Glu+Arg). The supplementation with 1% of glutamine did not affect the growth performance however, it reduced the mortality caused by ERE (39.1 vs 20% from 25 to 56 days of age), modified the intestinal microbiota and limited the presence of *Clostridium spp.* and

perfringens., *Campylobacter spp.* and *Helicobacter spp.* The additional supplementation with 0.5% of arginine did not improve any of those results.

PREDICTION OF ILEAL DIGESTIBILITY OF NITROGEN BY *IN VITRO* METHOD

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An enzymatic *in vitro* method was developed for predicting the crude protein (CP) and amino acids digestibility of 11 *in vivo* evaluated feedstuffs (proteaginous, cereals and their by-products and alfalfa) destined to rabbit diets. Both CP and amino acids were analysed in the feeds, feedstuffs and residues. The *in vitro* digestibility of crude protein was higher than the corresponding *in vivo* values (22.5, 11.9 and 5.8 points as average for apparent ileal, faecal and true ileal digestibility, respectively). The maximum difference was observed for fibrous feedstuffs and the minimum difference for oleaginous meals. The parameter most precisely predicted was the true ileal digestibility both for CP and limiting amino acids (coefficient of variation from 3 to 5.2%). Lysine digestibility was predicted with a similar accuracy than CP, methionine with higher and threonine with a lower accuracy than protein, however, the coefficients of determination of the amino acids equations were lower. When the amino acids digestibility was predicted from the *in vitro* CP digestibility similar precision was obtained. Therefore, the *in vitro* approach of protein digestibility seems to be appropriated for prediction of *in vivo* protein and amino acids true ileal digestibility.

IMPACT OF STARCH SUBSTITUTION BY LIPID DURING THE LATE PERIOD OF GROWING ON FEED CONVERSION RATE OF RABBIT

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The trial aimed to investigate the effects on rabbit growth and intake (48 to 70 days of age) of feeds where starch was partly substituted by lipids (from soya oil) to increase the digestible energy «DE» concentration (2450, 2550 and 2650 kcal DE/kg for I, II, III feeds resp.). Protein and amino acids on energy ratios were formulated as constant among the three feeds. 90 rabbits of 48 days of age were blocked in 30 replicates according to their weight and litter origin. Where the lipid level increased, the intake of rabbits

was not reduced (mean value 166.9 g/j) according to the increase in DE intake. This resulted in a better daily weight gain (+6%, $P=0.06$) and a lower feed conversion ratio (-7%, $P<0.01$). Since feeds had a similar ADF level, this support that intake is regulated on fibre intake more than on DE intake.

INFLUENCE OF FEED ENERGY LEVEL AT DIFFERENT DISTRIBUTION PERIODS ON GROWTH, MORTALITY AND RABBIT CARCASS YIELD

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A total of 672 rabbits were divided in 4 batches and raised from 5 weeks of age to slaughter. The objective was to test some feeds with three different digestible energy values (theoretical values of 2050, 2280 et 2690 kcal/kg) and given at different distribution periods (35-49 d and 49-71 d) on mortality, growth performance and carcass yield. The mortality was higher ($P = 0.05$) with rabbits consuming the high-energy diet during all the fattening period (35- 71 d) or only during the finishing period (49-71 d) (7.4% vs 2.4% in the batches consuming feed at 2050 or 2280 kcal/kg). The slaughter weight was not different among treatments. The post-weaning feed (35-49 d) didn't influence carcass yield. The high-energy diet fed during the finishing period increased carcass yield (61.3% vs 59.8%). The carcass fat was lower when the high-energy diet was given only during the finishing period (49 to 71 d).

NUTRITIVE VALUE OF DEHYDRATED BEET PULP FOR THE GROWING RABBIT

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The nutritive value of the dehydrated beet pulp was studied for the growing rabbit by comparing 3 diets containing an increasing incorporation rate of pulp: 0% (control), 15%, 30% in substitution to the control diet. The faecal digestibility of the diets were measured between 42 and 46 days of age, on three groups of 12 young rabbits fed *ad libitum* since weaning (35 d.). The digestible energy (DE) concentration of the beet pulp was estimated to 2750 kcal/kg (as fed basis), for instance 300 kcal over the values of the animal feeding tables (INRA 2004 or EGRAN 2002). The standard deviation of the mean for the DE concentration was 51.5 kcal. The mean digestibility of crude protein was estimated to 74.4%, corresponding to a digestible crude protein concentration of 57 g/kg (as fed basis).

ADAPTATIVE RESPONSE OF THE YOUNG RABBIT TO A HIGH-FIBRE FEED BEFORE WEANING: INTAKE BEHAVIOUR, GROWTH AND DIGESTIVE HEALTH

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Two groups of 19 litters were fed, *ad libitum* from 17 to 35 d of age, either a commercial feed for female (Control group) or an experimental high-fibre feed (Exp group). From weaning (35 d) to 49 d, the two groups were fed the high-fibre diet, and from 49 to 63 d old they were fed a commercial feed adapted to the growing rabbit. Between 17 and 21 d, the intake of the Exp group was half lower than control (28 vs 62 g per litter for 4 days, $P < 0.001$), and could be associated to the higher hardness of the fibrous feed (13.9 vs 11.2). Between 21 and 28 d the intake of the two groups was similar, then from 28 to 35 d the high-fibre diet was more consumed (+15%). Before weaning the growth of the young averaged 33g/d, without significant differences among the groups. From weaning to 42 d old, the mortality and morbidity rate were low ($\leq 6\%$) and not different among the groups. After 49 d old, the sanitary status decreased due to a colibacillosis. Morbidity increased but remained lower for Exp group (8.3 vs 19.2; $P < 0.01$ from 42 to 63 d), while mortality rate did not differ among groups (mean=29%). The young rabbit was thus able to adapt rapidly to a high-fibre diet since 3 weeks old. The stimulation of the intake, before weaning, using a high fibre diet, seems to continue after weaning.

INFLUENCE OF THE INCORPORATION OF A FIBROUS CONCENTRATE RICH IN LIGNIN ON THE MORTALITY, THE GROWTH AND THE SLAUGHTERING YIELD OF THE RABBITS

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During 2 successive trials, 2 330 rabbits weaned at 38 days of age were allotted according to a 2x2 factorial design with 2 dietary lignin levels (5.5 et 6.5%) and a presence/absence of a fibre mix extracted from the spruce wood (Arbocel®). The increase of the lignin level decreased of 2% in average the mortality between weaning and 55 days of age mainly by diarrhoea reduction. The Arbocel® incorporation dropped significantly the mortality by caecal paresis (-2%) in the second trial. The weights were similar among the 4 treatments (2.250 kg at 69 days); the

slaughtering yield was increased simultaneously by the increase of lignin level (+0.8%) and by the Arbocel® incorporation (+1.1%). Consequently, the utilisation of Arbocel® appears as a good solution to substitute other ingredients with high level of lignin.

COMPARISON BETWEEN 2 STRATEGIES OF FEED RESTRICTION BY WAY OF A LIMITED ACCESS TO WATER – TRIALS REALIZED IN SUMMER AND WINTER CONDITIONS.

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The interest of 2 strategies of feed restriction by way of a limited access to water was compared in summer and winter. 168 rabbits were distributed after weaning (32 d) in 3 groups in summer (336 rabbits in winter): A=control group, B=severe hydric restriction (1 h/d), C=progressive hydric restriction (1h30 to 3 h/d). In good sanitary conditions, the severe hydric restriction (during the first 3 weeks of growing) gives better results than the progressive one (better slaughtering weight: 2230 vs 2118g and better average daily gain during fattening: 40.6 vs 37.5 g/d), due to the compensatory growth in the end of the growing (+11.5% of growth for group B compared to the control group) and the feed conversion ratio improved (-5.8% of feed conversion ratio for group B during the whole fattening period compared to the control group). Nevertheless, the progressive hydric restriction makes the rabbits more safe during the whole growing period in case of bad sanitary conditions (less morbidity during 32-53 d: 41.4 g/d for group C vs 37.7g/d for group B, and less mortality: 6.3% for C vs 15.2% for B).

INTEREST OF TIME LIMITED ACCESS TO THE FEEDER (6 h, 8 h, 10 h PER DAY) FOR A QUANTITATIVE FEED RESTRICTION IN GROWING RABBITS

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320 young rabbits (weaned at 32 d) were distributed in 4 groups with different time to access the feeder (free, 6 h, 8 h, 10 h per day). A time limited access (6 h, 8 h, 10 h per day) during the first three weeks of growing allowed a quantitative feed restriction of respectively -37.2%, -26.1% and -19.6% of the *ad libitum* intake (free access). The adaptation of the young rabbits to the limited access was progressive (for instance for the 6 h per day group: -47.6%; -38.4% and -29.8% of feed intake compared to

the free access during the first 3 weeks). The feed conversion ratio was improved during the first three weeks of growing (-4.3 to -6.7% for 8 and 6 h per day respectively, $P=0.000$) but the slaughtering weight are significantly worse than the *ad libitum* group (-3.6%; -4.5% et -7.3% respectively for 10 h; 8 h and 6 h per day, $P=0.000$).

GENETICS

DIVERGENT SELECTION FOR LONGEVITY IN BREEDING DOES

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A divergent selection for functional longevity, based on genetic merit estimated through survival analysis techniques was carried out in the INRA 1077 rabbit line. The experiment was conducted to estimate the efficiency of such a selection and to analyse the consequences on other reproduction traits. Given the herd management, length of productive life was measured as the number of artificial inseminations without any culling for infertility for rabbit does. A total of 48 males were progeny tested based on the longevity of ten daughters. Based on their estimated genetic merit, 5 "high longevity" and 5 "low longevity" males were selected and produced a new generation (5 sons/sire). These 48 males were similarly progeny tested to estimate the direct and correlated responses to selection. A significant difference in longevity (+0.92 AI i.e 39 days) was observed between the two lines. Except for the total number born which was higher in the low line, there was no difference between the two lines for reproduction traits recorded for each kindling.

CANALISING SELECTION ON WITHIN LITTER VARIABILITY OF BIRTH WEIGHT IN RABBITS: RESPONSES TO SELECTION AND CHARACTERISTICS OF THE UTERUS OF THE DOES

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A divergent selection experiment on within litter homogeneity of birth weight in rabbits was carried out at INRA. The two lines have been created by selecting breeding does and bucks from the female

strain AGP22 bred at the Grimaud Frères Sélection Company. This involved a new model incorporating a genotypic value for the mean and a genotypic value for the environmental variance. There was a favourable selection response with a significant difference in within-litter standard deviation of birth weight between the lines selected for increasing (HOM) or decreasing (HET) the homogeneity. There was a favourable correlated response for the young survival at birth and from birth to weaning, and no effect of selection for variability on individual weight of young at birth. At the end of the 3rd and the 6th generation, females were sacrificed to collect the uterine horns and measure their initial length and their length after elongation with a weight of 50 g and then 70 g. The length and the elongation were significantly higher in the homogeneous line.

PHENOTYPIC COMPARISON OF RABBITS OF BREED BRUN MARRON DE LORRAINE RESULTING FROM EMBRYOS FROZEN IN 1992 WITH RABBITS OF THE SAME POPULATION AND ALIVE IN 2007

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Forty rabbits of the Brun Marron de Lorraine breed, issuing from embryos frozen in 1992, were compared phenotypically, at 6 months of age, to 39 rabbits of the same breed, descendants of the same families. There was a clear improvement of the conformation but a degradation of the shape of the head which swells instead of being angular. The mass of rabbits, their colour, under-colour and between colour remained unchanged. The authors thus note that the breed is not fixed and that the cryobank should allow to take into account this evolution. It would undoubtedly be useful to plan the freezing of embryos according to a determined rhythm, with defined intervals, to take into account the probable genetic variation of the rabbit breeds.

PRODUCTIVITY OF RABBIT DOES OF A WHITE POPULATION USED IN THE TIZI-OUZOU AREA IN ALGERIA

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Reproductive performance of 172 rabbit does of a white strain (638 litters) were registered in the Djelba rabbitry in Algeria between July 2005 and February 2007. Those does were mainly issued from commercial French hybrid rabbits imported in

Algeria in 1985-86, without external introduction since that time. Does were generally mated 8-14 days after kindling and eliminated after 3 infertile mating. Young were weaned when 30-35 days old. On average litter size at birth was 7.1 ± 2.4 total born, of which 6.7 ± 2.8 born alive. Litter size at weaning was 5.8 ± 2.4 . Stillbirth proportion was 7.3% of total kits born, and birth to weaning mortality was 15.8% of kits born alive. Prolificacy was similar to that observed for does of the local population, but kit's mortality was lower. The average does live weight at mating was 15% higher than that of the local population (3.34 vs 2.9 kg). Effects of parity and of season were also analysed.

REPRODUCTIVE PERFORMANCE OF PUREBRED WHITE NEW ZEALAND, CALIFORNIAN, AND GIANT BLANC DU BOUSCAT) AND HYBRID DOES KEPT UNDER UNCONTAMINATED CONDITIONS IN QUÉBEC

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This study was undertaken to evaluate the reproductive performance of purebred White New Zealand (NZ), Californian (CA), and Giant Blanc du Bouscat (GB) and crossbred does CA×NZ, GB×NZ and Nz×GB (sirexdam) bred in an uncontaminated environment. A total of 293 does were under investigation. Results showed significant differences ($P < 0.05$) for total born and weaned rabbits per litter, depending on does genetic background. In particular, CA×NZ does had the best results with 9.46 ± 2.40 total born and 8.65 ± 2.86 weaned rabbits per litter with a 44 ± 7 days littering interval. When compared to other crosses, the CA×NZ hybrids does performed specially well with regards to the regularity of reproduction and average annual productivity (58.8 rabbits weaned per year).

GROWTH PERFORMANCE OF SOME PUREBRED AND CROSSBRED RABBITS RAISED UNDER UNCONTAMINATED CONDITIONS IN QUÉBEC

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This study was conducted to compare growth performance from purebred White New Zealand (NZ) and Californian (CA) rabbits and from crossbred rabbits (CA×NZ, NZ×CA, Geant Blanc du Bouscat (GB)×NZ, NZ×(CA×NZ), NZ×(GB×NZ) et

NZ×(NZ×GB)) raised in a clean environment. Results from 861 litters (5733 rabbits) were collected during a 28 days growth test. Genotypes had significant ($P < 0.0001$) effects on rabbits growth performance. Rabbits with the NZ×(NZ×GB) genotype showed the best results for weight at 63 days of age (2461g), average daily weight gain (49.6 g/day) and feed conversion ratio (2.91).

ECONOMY AND RABBIT PRODUCTION

REVIEW: WHAT IS THE SUSTAINABILITY OF THE RABBIT PRODUCTION? ADVANTAGES AND LIMITS OF THE CURRENT BREEDING CONDITIONS

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This paper aims to specify the concept of sustainable agriculture and to present the principle, advantages and limits of the IDEA method, which evaluate the sustainability of farming. In the second time, the sustainability of the current rabbits breeding conditions is analysed using the IDEA method and discussed. Then, possible ways to improve the sustainability of rabbit breeding practices are presented. Lastly, an evaluation of the global environmental impact of the rabbit sector and the development of a tool more adapted to the landless breeding systems are justified.

A SURVEY ON RABBIT FARMS IN VENETO REGION: TECHNICAL DATA AND NITROGEN EXCRETION ESTIMATE

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A survey was performed on 48 rabbitries (breeding and fattening) located in Veneto Region to collect technical information and calculate nitrogen balance. Farms show great variability in dimensions (1216 ± 885 reproducing does and 7495 ± 5852 fattening rabbits), management and productivity. Fertility (76.8%) and other data of reproductive efficiency are significantly correlated with the number of rabbits sold/does/year, while independent from the number of reproducing does in the farm. The number of rabbits sold/does/year is 42.8 on average (from 28.9 to 60.9). The N excreted by the doe and its offspring is on average 7.40 ± 1.48 kg/year and significantly influenced by

slaughter weight ($P=0.05$) and number of rabbits sold/doe/year ($P<0.001$). The total nitrogen output of the whole rabbit production process corresponds to 65 ± 5 g of N per kg of rabbit produced alive.

MAIN RESULTS FROM RABBIT BREEDING REFERENCE FARM NETWORK CUNIMIEUX IN 2005-2006

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The rabbit breeding reference network CUNIMIEUX has provided since 1997 detailed information on rabbit breeding farms, farmers practices, technical performances and economical results. As an additional tool of technical and economical survey, it permits to follow the evolution of rabbit production from a hundred breeding farms sample distributed on the whole territory. This publication presents the results obtained in 2005-2006 on labour availability and working time in rabbit breeding farms, it analyzes the evolution of products and charges depending on the farm group and it puts forward an assessment of the production cost for a live kg of rabbit. Interest of artificial insemination and of breeding farm size increase in term of working time and remuneration of the farmer is confirmed.

ECONOMY OF THE FRENCH RABBIT PRODUCTION SINCE THE 80'S UNTIL NOWADAYS

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This synthesis analyses the evolution of French rabbit meat production since the 80's, on the one hand through some economic and statistical indicators, and on the other hand through national references of technical and economic results. Rabbit production has shown a downward trend in the long term with a strong reduction until the end of the 90s, due to the decline of the traditional and local production, yet it would steady since the beginning of the 2000s. Indeed the development of a rational and organized production during the 80s and 90s and the improvement of technical and economic breeding performances in those farms, showed in national references results, have permitted to stabilize volumes during the last years, even if rabbit epizootic enteropathy in 1997 and summer heat wave in 2003 were harshly undergone. This rationalization of the production has gone together with a concentration movement at each stage of rabbit industry and at geographical level.

MEAT QUALITY

BACITRACIN DIGESTIVE PHARMACOKINETICS IN RABBITS AFTER CONTINUOUS ADMINISTRATION THROUGH DRINKING WATER OF A HYDROSOLUBLE VETERINARY MEDICINAL PRODUCT. SYSTEMIC BIOAVAILABILITY AND TISSUE RESIDUES DETERMINATION

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Bacitracin was administered continuously through drinking water in four groups of growing rabbits at doses of 105, 210, 420 or 840 IU/kg b.w. using a hydrosoluble medication (Bacivet®-S) for seven consecutive days. Coecal samples were taken at times 0, 4, 8, 12 and 24 hours on days 3 and 7 of medication. These samples were analysed using liquid chromatography with tandem mass spectrometry detection (LC/MS/MS). The results obtained showed that caecal bacitracin concentrations remained constantly above the Minimum Bactericidal Concentration (MBC) at the dose of 420 IU/kg b.w. In addition, after 30 days of continuous administration at 420 IU/kg b.w., blood concentrations remained below the detection limit (<37.5 µg/L). As a consequence, no residues were found (<75 µg/kg) from the first day after treatment withdrawal in any edible tissue.

NUTRITIONAL ASSETS OF RABBIT MEAT: COMPARISON WITH OTHER MEAT PRODUCTS

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The aim of this study was to determine the nutritional value of meat of rabbit raised under the current conditions of production for the French market. Energy, proteins, dry matter, minerals, lipids, cholesterol and fatty acids content were measured on cooked or raw minced meat sample arising from 10 boned carcasses whose fat was not removed. Compare to other meat products, rabbit meat presents a high nutritional interest such as a moderate lipids content (9 g/100g cooked meat), a ratio omega6/3 of 8, a low sodium content (49 mg/100g cooked meat) and a relatively high selenium content (77 µg/100 g of cooked meat).

EFFECT OF A DECREASING OMÉGA 6/OMÉGA 3 RATIO ON FATTY ACID CONTENT OF RABBIT MEAT

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Four groups of 15 rabbits were fed from 35 to 71 days four different diets (oméga3-, Standard, oméga3+ or oméga3++) with decreasing oméga6/oméga3 ratio (12.4; 7.7; 4.0 and 1.6 respectively). A fifth group received Standard diet from 35 to 50 days and oméga++ diet until 71 day of age. The decrease of the oméga6/oméga3 ratio of the diet had no effect on the growth performance, mortality and dressing percentage. Meat linolenic fatty acid (C18 3n-3) content from Standard group covered 15% of the man and the woman ANC (Apport Nutritionnel Conseillé). A diet enriched in oméga 3 distributed during the last fattening period allowed producing meat whose C18:3n-3 content raised 46% of ANC.

EFFECT OF PASTURE AVAILABILITY ON ACIDIC PROFILE AND TBARS CONTENT OF RABBIT MEAT

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To verify the effect of organic rearing system on the fatty acid profile of rabbit meat, 100 New Zealand White rabbits were assigned to two homogeneous groups: control group reared in standard cages (17 rabbits/m²) and organic group in pen provided of a grass pasture area (20m²/rabbit). Acidic composition and Vitamin E homologues content of feed and pasture were assessed; the same parameters, together with the index of lipid peroxidation were also evaluated in two retail cuts. A higher content of n-3 long chain polyunsaturated fatty acid was found in both *biceps femoris* and *longissimus dorsi* of rabbits reared in organic system with respect to control, whereas a higher oxidative stability was found only in *longissimus dorsi* of organic rabbits according to the higher content of this muscle in tocophérols. These results support that organic rearing system and in particular grass ingestion and exercise could be useful in improving rabbit meat nutritional quality.

EVALUATION OF THE QUALITY TRAITS OF CARCASSES FROM THREE BATCHES OF COMMERCIAL RABBITS (STANDARD, CERTIFIED AND LABEL) IN AN INDUSTRIAL SLAUGHTER-HOUSE, USING 41 EASY, FAST AND CHEAP PHYSICAL OR CHEMICAL MEASUREMENTS

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A total of 41 physical or chemical measures for carcass and meat quality traits, were obtained in an industrial slaughterhouse on 2 series of 300 rabbits from 3 commercial batches: Label, certified and standard. They related to retail cuts weights, meat color, ultimate pH, electrical conductivity (ToBEC), and mechanical characteristics of the meat and bone femur. This experiment showed 1) the reliability of these measurements in an industrial slaughterhouse 2) the variability of these measurements according to rabbit batches, and demonstrated that 3) only adiposity, meat to bone ratio, proportion of thigh relative to carcass weight, proportion of femur relative to thigh or carcass weights, and femur flexure tests did not show any interactions between slaughtering series and batches.

ABILITY OF PHYSICO-CHEMICAL MEASUREMENTS TO DISCRIMINATE RABBIT MEAT OF THREE DIFFERENT REARING SYSTEMS

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The aim of this study was to identify a limited number of physicochemical measurements that could differentiate rabbit meat in an industrial slaughterhouse. Three different rearing systems were considered: standard production system, a high quality norm system (Label) or a certified breeding system. Data were processed using decision tree analysis (DTA). A first DTA selected 2 variables (femur stiffness, and *longissimus dorsi* pHu) to discriminate between the three groups; however the correct assignment score was poor (60%). A second DTA was build to discriminate only between Label group and the two other groups. A total of 76% of rabbits was correctly assigned to their original rearing group, by using only one mechanical criterion (bone femur stiffness).

PATHOLOGY: RABBIT EPIZOOTIC ENTEROPATHY

SUSCEPTIBILITY, RESISTANCE AND BACTERICIDAL PROFILE OF BACITRACIN AGAINST *CLOSTRIDIUM PERFRINGENS* STRAINS ISOLATED DURING OUTBREAKS OF RABBIT EPIZOOTIC ENTEROPATHY

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Bacitracin Minimum Inhibitory Concentration (MIC) against *Clostridium perfringens* strains isolated during outbreaks of Epizootic Rabbit Enteropathy was determined as an MIC₉₀ of 0.93 µg/ml. No strains were resistant to bacitracin and serial passages in the presence of sub-inhibitory concentrations failed to induce the development of resistant strains. Bacitracin could be described as a concentration-independent bactericidal antibiotic. Bactericidal activity was obtained at a concentration corresponding to twice the MIC and did not further increase at higher levels. This profile is in favour of continuous administration, e.g. in drinking water.

BACTERICIDE KINETICS OF TIAMULIN FOR STRAINS BELONGING TO CLOSTRIDIUM GENUS OF RABBIT ORIGIN

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The episodes of Rabbit Epizootic Enteropathy (REE) remain partially resolved. Enteric bacteria belonging to *Clostridium* genus are known to be more frequently isolated during the imbalance of the intestinal ecosystem in the disease etiology. Among the antibiotic gear used against REE, tiamulin is an antibiotic of choice which targets *Clostridium*. In this study, *in vitro* techniques allowed to determine the efficiency of this pleuromutilin at 2, 4; 8 and 16 times the MIC by performing bactericide kinetics over a period of 24 hours and for 3 strains of *Cl. perfringens*, 2 strains of *Cl. difficile* and 1 strain of *Cl. sordellii* freshly isolated in 2004 from rabbit caeca heavily affected by the disease. During the first six hours of contact, a significant decrease was observed without any regrowth phase at 24 hours. The curve of bactericidy complies with a time-dependant effect.

IN VIVO STUDY OF THE SUPERNATANT OF THE INOCULUM TEC4, USED FOR EXPERIMENTAL REPRODUCTION OF EPIZOOTIC RABBIT ENTEROPATHY (ERE)

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The supernatant, obtained by centrifugation (8000 or 40000 g) from the TEC4 inoculum, was studied through 5 trials carried out “*in vivo*”, aiming at supporting the hypothesis that a preformed toxin is present in the inoculum. We particularly analyzed the repercussions of an oral or parenteral administration, associated with the effect of heat applied to this fraction. The results confirm that a toxic product was responsible for the early physiological disturbance (D1-D2 after inoculation) marked sometimes by a severe decrease of the daily weight gain. These trials have also made it possible to set aside the direct implication of a virus in the genesis of the ERE.

PATHOLOGY

DEVELOPMENT OF A NESTED PCR TECHNIQUE FOR THE DETECTION OF *CLOSTRIDIUM PILIFORME*, TYZZER'S DISEASE AGENT

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In front of limits of diagnosis methods to detect *Clostridium piliforme*, Tyzzer's disease agent, a novel technique of nested PCR was developed. The specificity of this technique for *Clostridium piliforme* was checked with regard to the most phylogenetically close bacterial strains (on basis of 16S RNA sequence analogies). The sensibility of this technique from clinical samples was demonstrated.

ISOLATIONS, CULTURES AND ANTI BIOGRAMS ON CLOSTRIDIUM SPIROFORME ORIGINATING FROM RABBIT'S FARMS

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Enterotoxemia due to *C. spiroforme* is frequently involved in digestive diseases of rabbit. In France isolation and antibiogram aren't used in diagnosis laboratories. Specific caecal samples were obtained and after a pre-treatment, isolation of the bacteria

and antibiogram were carried out. By this method, bacitracin, ceftiofur and doxycyclin were efficient. In vitro, *C. spiroforme* was not always sensitive to tiamulin. Nevertheless in farms tiamulin is an efficient treatment and the results are bad with bacitracin. CMI investigation by another method of antibiogram, like successive dilutions in agar medium, could better define the sensitivity of isolated strains in vitro, specially for tiamulin and doxycycline.

ANALYSIS ON DOES UTERUS: RELATION BETWEEN CLINICAL SIGNS, GROSS LESIONS AND BACTERIOLOGY

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The records of 179 bacteriological analyses originating from does uterus over 2006 have been studied. Hundred five cultures were positive and 74 negative. Bacterial species were: 46.8% *Staphylococcus aureus*, 23.4% *Pasteurella multocida*, 23.4% *E. coli*. 69.6% of isolated strains of *S. aureus* were related to uteruses without macroscopic lesions. Whatever the pathogenic germs implied (*S. aureus*, *P. multocida*, *E. coli* with *eae* positive PCR), in the event of lesions, those are mainly purulent. The uterine bacteria were not systematically recovered on other organs.

IMPACT OF FEED MYCOTOXIN CONCENTRATION ON PERFORMANCES, MORTALITY AND ANTIOXIDANT STATUS OF GROWING RABBITS

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The aim of this trial is to determine the effect of mycotoxin infected wheat (high levels of vomitoxin and zearalenon) on zootechnical and blood antioxidant parameters of fattening rabbits. No significant difference appeared on growth parameters between the treatments (from 0 to 2.13 ppm of vomitoxine analysed). Nevertheless, feed intake and feed conversion rate were improved between 52 and 70 days of age with the increase of mycotoxin level. Lastly, the KRL test allowed to detect rabbits who consumed infected feed. Thus, the intake of infected feed led to an increase of the antiradical answer. From 0.33 mg/rabbit/day of vomitoxin or 0.40 mg/rabbit/day, the antiradical drop down because of the very high feed contamination.

ASSESSMENT OF THE TECHNICAL AND ECONOMICAL IMPACT OF DIGESTIVE DISEASE IN FATTENING RABBIT. INTEREST OF TREATMENT STRATEGY

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Between 2003 and 2006, Elanco performed 3 studies in experimental stations showing a digestive disease environment. The economical impact of an episode of digestive disease is assessed to 0.78 €/rabbit. Whatever the therapeutic strategy put in place (preventive or curative according to the farm history), the return on investment is positive: 5.1 and 9.15 in average respectively.
