



EFFECT OF A DIETARY SUPPLEMENTATION OF SACCHAROMYCES CEREVISIAE MUGL 39885 ON FATTENING PERFORMANCE IN GROWING COMMERCIAL RABBITS AND A META-ANALYSIS

Platonova N. P., Doctor of Science, <https://orcid.org/0000-0003-2256-7932>
Institute of animal science of NAAS of Ukraine / Adam Mickiewicz University in
Poznań, Poznań, Poland

A study was conducted to determine the effect of Saccharomyces cerevisiae supplementation in the diet of growing rabbits on their mortality, fattening performance and feed conversion rates.

In a pooled analysis, supplementation of Saccharomyces cerevisiae to the diet of growing rabbits caused a significant increase in final weight by 132.24 g (non-standardized average difference). According to the obtained data, there is a systematic error associated with publication bias (Egger's test, $p < 0.001$) and high heterogeneity between studies ($I^2 = 92.9\%$, $p < 0.001$). The results of the Q-test ($\chi^2 = 282.733$) and its p-level (< 0.001) indicate the occurrence of statistically significant heterogeneity and the null hypothesis which states that all studies share a common effect size was rejected. The effect of Saccharomyces cerevisiae administration was not characterized by statistically significant variation in the genetic subgroups of rabbits (test for subgroup differences: $p = 0.759$). In parallel there was a statistically significant variation in subgroups of SC dose (test for subgroup differences: $p = 0.04$). When a higher concentration of Saccharomyces cerevisiae was used, the average final weight in the experimental group was 209.23 g higher than the final weight in the control group. When a lower concentration of SC was used, the average final weight in experiment was more than the control by 93.38 g.

In own researches Saccharomyces cerevisiae (MUGL 39885, 0.01% - 15 billion cell per gram) was added to the feed for the experimental group before granulation. After 37 days of fattening, the control group reached an average weight of 2230 g, whereas the weight for the experimental group was 2608 g, probably due to the better FCR in the experimental group. Both mentioned differences were significant. Whereas the daily feed intake did not differ in the studied groups. Comparison of the rabbit survival in each group showed no significant difference for the one-sided t-criterion ($p = 0.097$).

Therefore, the usage of feed with Saccharomyces cerevisiae additive affects the results conceding rabbits fattening. Experimental group obtained the statistically significant best average final weight, daily gain and feed conversion ratio in the same raising conditions. It confirms the results obtained from the meta-analysis. At the same time, there is no statistically proven change in feed intake between groups, and that is a promising and important economic and ecological result.

Keywords: growing rabbits, Saccharomyces cerevisiae, fattening performance, meta-analysis.

The usage of antibiotics for treatment and prevention of animal diseases is a serious challenge in terms of increasing resistance of pathogenic bacteria. It was banned for meat (including rabbit meat) producers in the European Union to use antibiotics as growth promoters in livestock production in 2006 [1]. However the weaning period may



be very critical, when kits are separated from does and don't receive maternal milk. Mortality rate of young rabbits after weaning can be high if there are non-optimal keeping and feeding conditions [2].

We use the traditional term "probiotics" in the definition given by the US FDA (Food and Drug Administration). There is a more comprehensive term "direct feed microbial" (DFM) – "DFM is a source of naturally occurring live microorganisms" including bacteria and fungi [3].

In view of the great variability of DFM, it is necessary to take into account specifics of the administration forms and biological properties: the resistance to gastric acidity and ferments, the adhesion to epithelial cells, the antimicrobial activity, the relationships with the pathogenic bacteria, antibiotic resistance, the relationships to other feed additives, and the stability in the feed forms [4].

The positive effects of DFM (in our study - various strains of *Saccharomyces cerevisiae* (SC)) for the gastrointestinal tract are complex. They may improve food digestibility by developing intestinal villi and enhancing their absorptive capacity and protect the digestive tract from pathogenic bacteria.

One of the problems of livestock production is its contribution to global greenhouse gas emissions. So there is a sense in usage of probiotic additives to improve digestibility and reduce the contribution of livestock production to global greenhouse gas emissions [5]. However some studies report about the efficiency of diets with SC, while others report about unsuccessful experiences.

Different technological and hygienic conditions for keeping rabbits, usage of different strains of SC and different genetics of rabbits make it difficult to obtain reliable results with additives – alternatives to antibiotics including probiotics SC [6].

There are publications of experiment results on probiotic dietary additives for rabbits that give an opportunity to do a complex analysis (e.g. meta-analysis) for a more reliable evaluation of efficiency of using probiotics (SC) in meat rabbit's diets. It will help consolidate different results for a better understanding of processes and further practical usage. This information is very important because feed costs are the highest in the cost structure of industrial farms. Improving feed conversion and increasing the final weight of meat rabbits are crucial factors for the economic efficiency of production as long as antibiotics are not being used.

Therefore, the purpose of our study is to evaluate the effect of SC-based feed additives as an alternative to antibiotics for the final body weight changes and FCR of young rabbits by meta-analysis of the available publications.

Materials and methods. The purpose of meta-analysis is to evaluate the effectiveness (weight and feed conversion rates) of nutritional additives SC in rabbits nurturing.

Criteria for study selection.

We have searched the online databases Google Scholar and Web of Science for relevant keywords: rabbit, weight, "feed conversion ratio" OR FCR, "*Saccharomyces cerevisiae*" OR probiotic. And then we checked the literature sources cited in the received articles and used them in our study if they were available in full-text version and data were not repeated. When the study contained data from several experiments, each such experiment was considered separately.

Articles for inclusion in meta-analysis were selected using the following criteria:

- 1) Studies were published between 1995 and 2022;
- 2) SC must be administered through feeding;
- 3) Rabbits shouldn't receive any additional treatment at the time of the experiment;



- 4) There are at minimum 10 rabbits per group;
- 5) Studies must report about feed conversion ratio (FCR) (or there was a possibility to calculate it) [8], average weight of rabbits at the start and finish of the experiment;
- 6) Studies must report about diet composition;
- 7) Rabbits were 30-42 days old at the beginning of the experiment and 58-91 days old at the end of the experiment;
- 8) Type of feeding is complete feeding, "ad libitum";
- 9) Data of weight and FCR have descriptive statistics;
- 10) Scientific data were published in reviewed scientific journals;
- 11) There must be no duplication of data of the same scientific papers with the same authors.

The inclusion criteria were met by 12 scientific articles (662 scientific papers were reviewed, 12 scientific articles which contain information about 21 experiences were selected).

The results of the studies that observed groups of rabbits which differed significantly in live weight, feed conversion, and housing conditions were not identical. Different strains of SC were used, including commercial strains. Based on these conditions, we initially consider using a random-effect model (using the Sidik and Jonkman method with corrections by Hartung and Knapp [cite by 9]).

Meta-analysis was performed using continuous data, as the size effect was used Hedges' g and the non-standardized average difference.

Tests for homogeneity of effect sizes were based on Q-statistics, in which larger Q values point to higher heterogeneity of effect sizes. A quantitative estimate of statistical heterogeneity was also calculated (I^2).

A significance level (p-level) <0.1 for the Egger regression coefficient was considered as an indicator of significant systematic error in the publication. Subgroup analysis and regression meta-analysis were performed to determine the source of heterogeneity. The publication bias error was investigated using the Egger regression test.

Separate subgroups related to the genetics of studied rabbits were identified. There was no influence of the genetics factor on the effect size. That's why the subgroups associated with different concentrations of SC in studies were distinguished. The variation of effect within the subgroups was statistically significant.

A meta-analysis was performed separately for measures of rabbit's weight at the end of the experiment and FCR for the study period.

The main parameters of the experimental data in the articles reviewed for this research are in Table 1.

A meta-analysis of the change in mortality due to the adding of SC to the diet was performed using dichotomous data based on whether the phenomenon was observed.

We searched the online databases Google Scholar and Web of Science for relevant keywords: rabbit AND mortality AND "Saccharomyces cerevisiae"

Articles for the meta-analysis were selected using the following criteria:

- 1) Studies were published between 1992 and 2022;
- 2) SC must be administered through the feed;
- 3) Rabbits shouldn't receive any additional treatment at the time of the experiment;
- 4) There are at minimum 20 rabbits per group;
- 5) Scientific data were published in reviewed scientific journals;



6) There must be no duplication of data of the same scientific papers with the same authors.

Table 1

Main parameters of experiments on the effect of feed additive SC on the performance of rabbit's production

Author, year	Ref.	genetic	N	variants of experiment (concentration)	Start age, days	Days of exp.
Jerome N. 1996	[9]	NZW	300	1	30	28
Jerome N. 1996	[9]	NZW	300	2	30	49
Onifade A. 1999	[11]	hybrid	10	1	35	49
Onifade A. 1999	[11]	hybrid	10	2	35	35
Lambertini L. 2004	[12]	NZW	24	1	35	35
Kimse M. 2012	[13]	NZW	32	1	35	56
Kimse M. 2012	[14]	NZW	32	2	35	56
Rotolo L. 2014	[14]	hybrid	40	1	30	49
Rotolo L. 2014	[14]	hybrid	40	2	30	49
Belhassen T. 2016	[15]	NZW	30	1	28	42
El-Kelawy H. M. 2016	[16]	hybrid	15	1	28	42
Ayyat M.S. 2018	[17]	hybrid	10	1	28	42
Awad Sh. 2019	[18]	hybrid	10	1	35	35
Abdel-Aziz Elsayy B. 2021	[19]	hybrid	15	1	35	35
Abdel-Aziz Elsayy B. 2021	[19]	hybrid	15	2	35	35
Abdel-Aziz Elsayy B. 2021	[19]	hybrid	15	3	35	35
Elmasry A.M.A 2021	[20]	NZW	12	1	35	35
Elmasry A.M.A 2021	[20]	NZW	12	2	35	35
Elmasry A.M.A 2021	[20]	NZW	12	3	35	35
Elmasry A.M.A 2021	[20]	NZW	12	2	35	35
Khan K. 2021	[21]	NZW	12	1	42	48

The effect size of dichotomous results was based on whether the mortality of rabbits during the experiment was observed in both groups. The risk difference was used as the effect size. The raw data was used for the risk difference calculation. The results of 13 experiments from 7 publications from 1992 to 2016 were used.

For the meta-analysis, we used a randomized model, raw binary data, and log-risk ratio as the effect size (estimation method by Sidik and Jonkman, method MSE correction by Hartung and Knapp) (software Jamowi 2.2.5).

Own studies

Animals. Studies were conducted on commercial hybrid (Hy-Plus) rabbits aged 35-72 days which were housed in the industrial rabbit farm (Ukraine, Kiev region, Vyshgorod district). Two hundred rabbits were divided into two similar groups (age, weight, health status). Each group was divided into 20 cases per 5 rabbits. The experiment duration was 37 days. Rabbits of both groups were weighed individually at the beginning of the experiment (weaning, age is 35 days) and at the end of the fattening



on the 37th day of the experiment. Daily feed intake and feed conversion ratio were determined in groups (including mortality).

Feeding and drinking. Drinking was provided automatically by the nipple system (1 nipple for max 5 rabbits). Complete pelleted diets were used to cover the rabbits' physiological, nutritional needs and their productive performance. Feeding was poured into plate-type bunker feeders (1 bunker feeder between two cages, full volume of bunker 2.7 kg pellets). The length of the feeding table for each rabbit was at least 8 cm. The food was available all the time. The feeding was ad libitum. The chemical composition of the basic feed is indicated on Table 2.

Table 2

The chemical composition of the diet for growing rabbits

Chemical composition (1 kg)	Quantity
Dry matter	88.5%
Crude fibre (CF)	17.55%
Crude protein (CP)	17.65%
Starch	14.2%
Lipids	3.7%
Ca	1.19%
P	0.74%
Na	0.23%
Mineral and vitamin premix	include
Gross energy	9.2 MJ

Saccharomyces cerevisiae MUGL 39885 (Biosprint), 0.01% (15 billion cell per gram) was added to the feed for the experimental group before granulation.

Rabbits' housing conditions. Microclimate parameters were regulated automatically. Air exchange was provided by industrial ventilators and was 3-3.5 m³ of air per hour per 1 kg of total live weight of rabbits housed. The temperature was +18-+22°C. Immediately after weaning, rabbits were put in group cages (5 rabbits per cage) with a gridded floor with area 0.36 m² (0.4×0.9 m). At the end of the fattening period (72 days of age) the housing density did not exceed 35 kg per m². This stocking density did not exceed the recommended values EFSA (European Food Safety Authority) as a 'safe' stocking density from the perspective of rabbit welfare (40 kg slaughter weight/m² at 2.5 kg slaughter weight) [22]. Type of the floor was a wire mesh (12.5mm*75mm and wire diameter 1.8 mm). Ulcerative pododermatitis has not been found in any of the studied rabbit groups. There was a low level of light. Lights were turned on only when technologically necessary.

The vaccination programs include myxomatosis and rabbit hemorrhagic disease only for does, males and young rabbits selected for breeding.

Reproductive rhythms were based on AI at 18 days post-partum, which meant an interval of 49 days between two kindling's and all kits of a particular group were born on the same day.

Statistical analysis. The results were analyzed with the IBM SPSS Statistics (v. 28.0.1.1 (15)), ANOVA: control group (basic feed) and experimental group (basic feed with SC). The variance analysis was based on weight data (individually) and on FCR, feed intake and daily weight gain (in cages). Comparison of the proportions of rabbit survival in each group was performed with one-sided t-criterion.



Research results and discussions.

The effect of SC diet additives of the growing rabbits on final weight.

In a pooled analysis, SC supplementation to the diet of growing rabbits caused a significant increase in final weight by 132.24 g (78.53; 185.95, $p < 0.001$) (non-standardized average difference). According to the obtained data, there is a systematic error associated with publication bias (Egger's test, $p = <0.001$) and high heterogeneity between studies ($I^2 = 92.9\%$, $p < 0.001$). The results of the Q-test ($\chi^2 = 282.733$) and its p-level (<0.001) indicate the occurrence of statistically significant heterogeneity and the null hypothesis which states that all studies share a common effect size was rejected (Fig. 1).

Genetic subgroups of rabbits.

The effect of SC administration was not characterized by statistically significant variation in the genetic subgroups of rabbits (test for subgroup differences: $p = 0.759$).

Subgroups of SC dose.

There is a statistically significant variation in subgroups of SC dose (test for subgroup differences: $p = 0.04$). When a higher concentration of SC was used, the average final weight in the experimental group was 209.23 g CI 95% (87.90; 330.57) higher than the final weight in the control group. When a lower concentration of SC was used, the average final weight in experiment was more than the final weight in control by 93.38 g CI 95% (45.25; 141.51).

Due to the high level of heterogeneity in the data, meta-regression was applied in an effort to find the source of heterogeneity. Fisher's criterion of the meta-regression model is significant ($F=4.24$, $df (4; 16)$, $p=0.016$) (Table 3).

Table 3

Estimation of regression models parameter (final weighting)

Parameter	Estimated	SE	T	p-level	95 % CI	
					Low	High
Intercept	-223.188	91.654	-2.435	0.027	-417.49	-28.89
Year of publication	0.108	0.044	2.456	0.026	0.015	0.201
Crude protein	1.006	0.506	1.987	0.064	-0.067	2.079
NDF	-0.177	0.110	-1.606	0.128	-0.411	0.057
Days of experiment	-0.096	0.048	-2.02	0.06	-0.197	0.005

In publications prior to 2016, there was practically no visible difference in weight between the experimental and control groups. In later publications, it has improved markedly. We cannot say for sure yet whether it is the evolution of the commercial SC strains, the genetic improvement of industrial breeds and hybrids of rabbits or modernization of housing and feeding technology. It is more likely to be the result of the combined effect of these factors (Fig. 2).

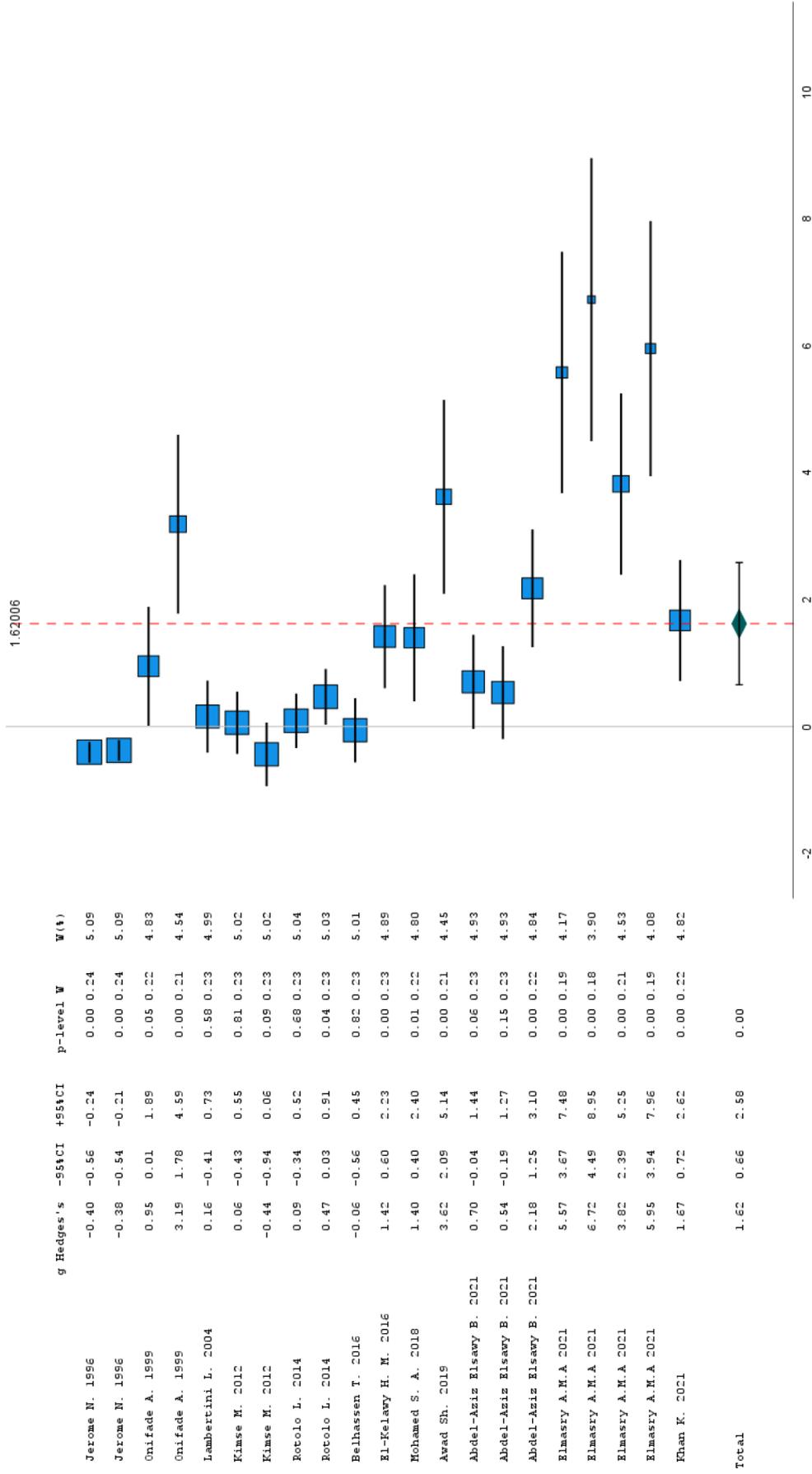


Fig. 1. Forest plot for the result of meta-analysis (final weight of rabbits)

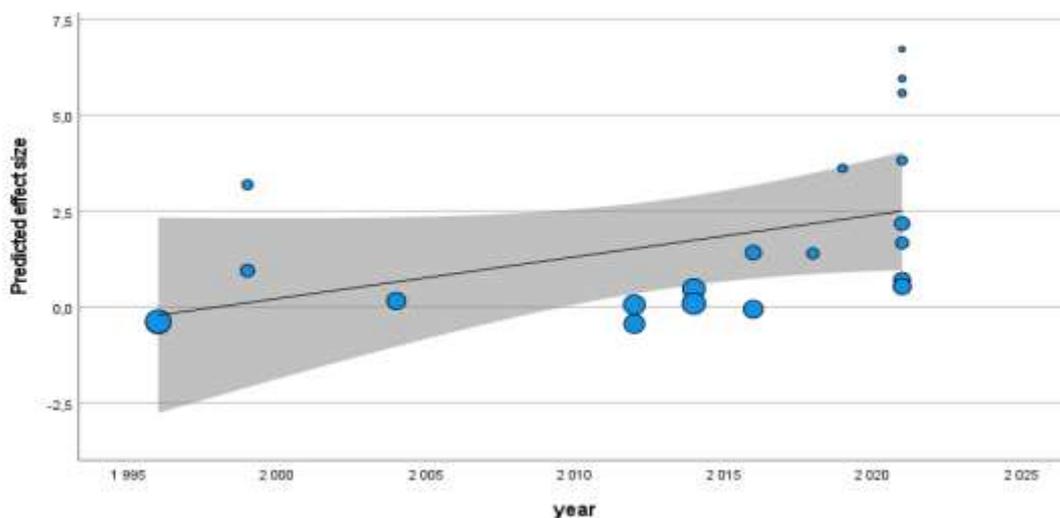


Fig. 2. Relation between predicted effect size (final weight) and year of publication

Effect of SC supplementation on FCR of growing rabbits.

In a pooled analysis, SC supplementation to the diet of growing rabbits caused a significant improvement in final FCR: ES= -0.36 (-0.51; -0.21, $p < 0.001$). According to the obtained data, there is a systematic error associated with publication bias (Egger regression test, $p < 0.001$) and high heterogeneity between studies ($I^2 = 96\%$, $p < 0.001$). The results of the Q-test ($\chi^2=159.05$) and its p-level (< 0.001) indicate the occurrence of statistically significant heterogeneity and the null hypothesis which states that all studies share a common effect size was rejected (Fig. 3).

There was a statistically significant effect of variation in SC dose (“conc.”) on FCR (test for subgroup differences $p = 0.03$). When a higher concentration of SC was used, the average FCR was less than the FCRc by -0.68 (-1.15; -0.22). When a lower concentration of SC was used, the average FCR was less than the FCRc (less means better) by -0.19 (-0.3; -0.07).

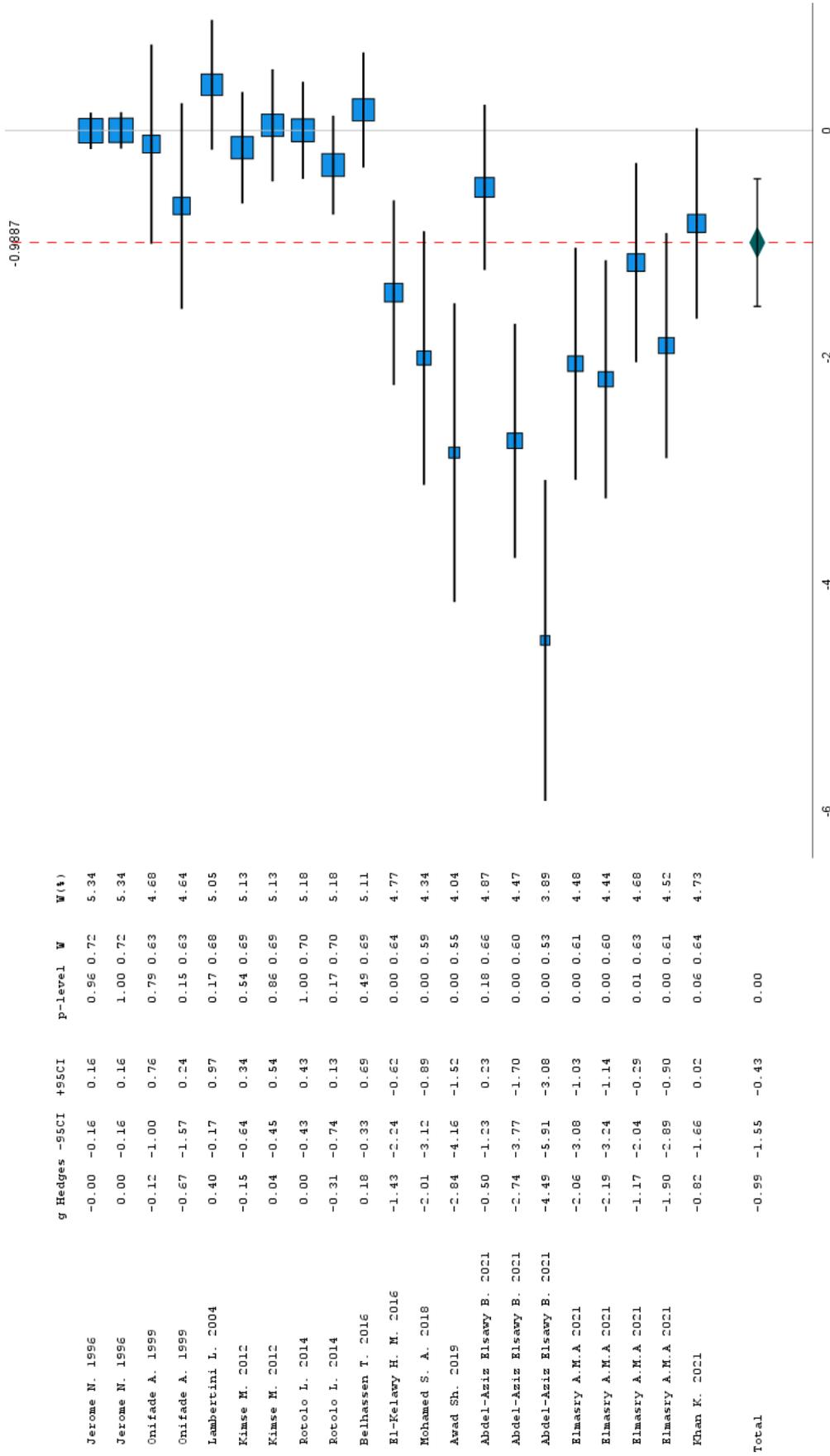
Also statistically significant variation was observed in subgroup “breed” on FCR (test for subgroup differences: $p = 0.02$). FCR in hybrid rabbits decreased by 0.28, 95% CI (-0.50; -0.07), and in NZW rabbits FCR decreased by 0.45, 95% CI (-0.69; -0.21).

Fisher's criterion of the meta-regression model is significant ($F=6.84$, $df(5; 15)$, $p=0.02$) (Table 4).

Table 4

Estimation of regression model parameter (FCR)

Parameter	Estimated	SE	T	p-level	95% CI	
					Low	High
Intercept	170,244	43,749	3,891	0,001	76,995	263,494
Year of publication	-0,081	0,021	-3,870	0,002	-0,126	-0,036
Days of experiment	0,043	0,023	1,880	0,080	-0,006	0,091
Concentration	-0,584	0,3779	-1,546	0,143	-1,390	0,221
Breed	-0,837	0,3788	-2,210	0,043	-1,644	-0,030
Crude protein	-0,449	0,2208	-2,035	0,060	-0,920	0,021



Heterogeneity: $I^2 = 1.38$, $H^2 = 25.24$, $I^2 = 0.96$
 Homogeneity: $Q = 159.05$, $df = 20$, $p\text{-level} < 0.001$
 total effect size criterion: $t = -3.67$, $df = 20$, $p\text{-value} = 0.00$

Fig. 3 - Forest plot for the result of meta-analysis (FCR)

As for the year of publication, its relation to the improvement of FCR (decrease in the index FCR) is understandable in terms of the improvement of commercial strains SC, industrial farm technology and genetics of rabbits (Fig. 4).

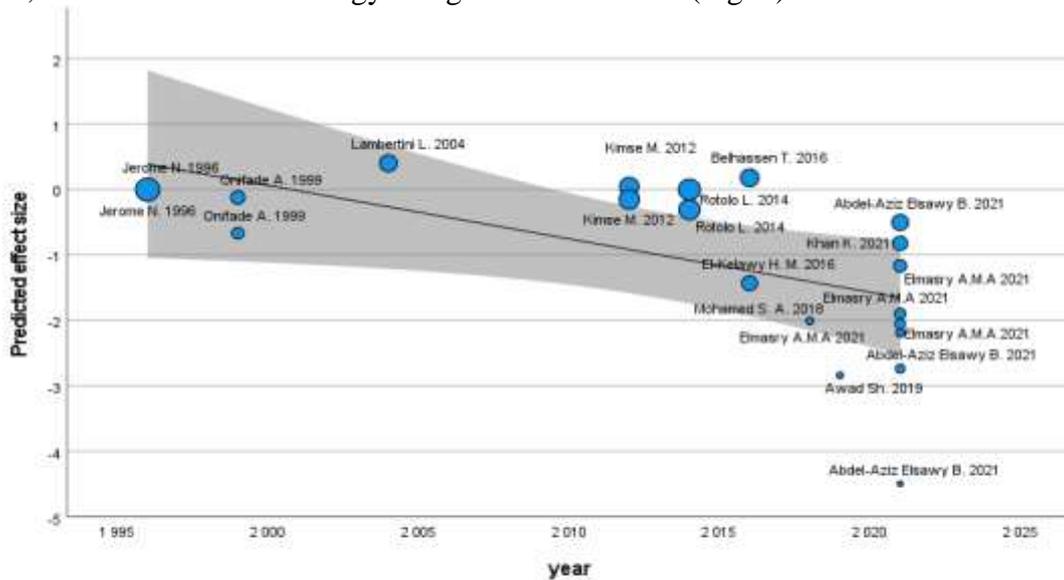


Fig. 4. Relation between predicted effect size (FCR) and year of publication

Absolute values of FCR have a provable and distinct tendency to increase with age of rabbits, so the observed variation complies with the standard parameters associated with the biology of development [23] (Fig. 5). In intensive European rabbit breeding farms, the total FCR decreased from 3.8 to 3.4 during the past 15 years (average slaughter weight is 2.43 kg) [24].

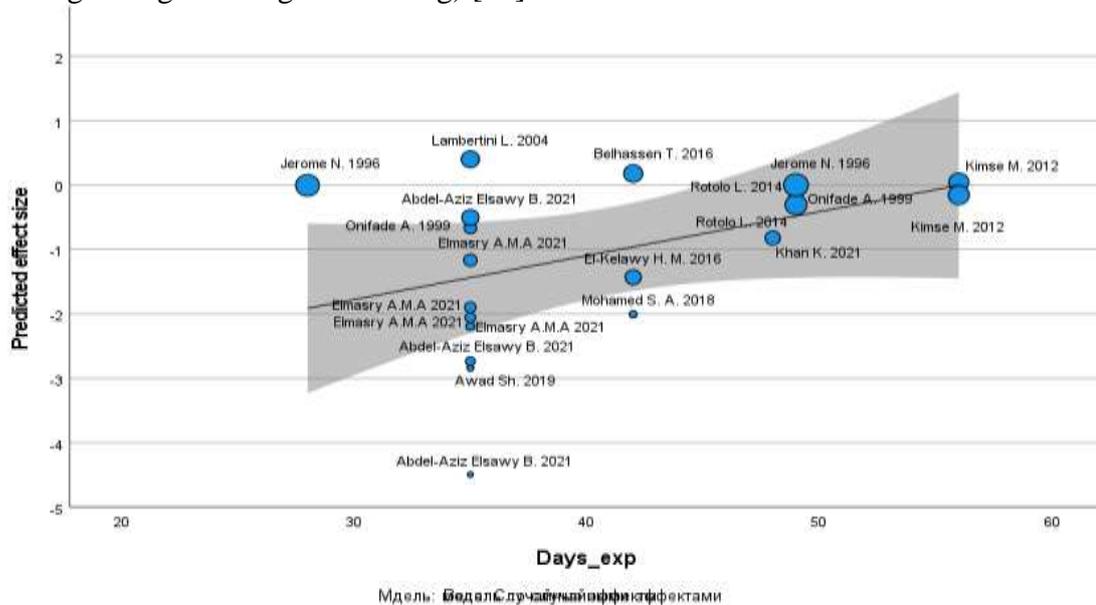


Fig. 5. Relation between predicted effect size (FCR) and duration of experiment



The improvement in FCR associated with an increasing SC concentration has already been discussed in the subgroup analysis. As far as genetics is considered, hybrid rabbits are generally characterized by better conversion rates than purebred NZW [24].

Effect of SC supplementation on daily feed intake of growing rabbits.

In summary analysis, SC supplementation to the diet of growing rabbits did not cause significant changes in daily feed intake: ES=0.067 (-0.205; 0.339, p = 0.612). Based on the findings, systematic error due to publication bias is not proven (Egger regression test, p =0.235). There is high heterogeneity between studies ($I^2 = 83.7\%$, p < 0.001). Q-test results ($\chi^2 = 93.517$) and its p-value (< 0.001) indicate the occurrence of statistically significant heterogeneity and the null hypothesis was rejected (Fig. 6).

A meta-analysis provides an overview of the effect and its evidence, even if a significant effect of the SC was not found in individual studies.

Conducting a meta-analysis gives an opportunity to see the generalized effect of the studies and motivates the studies so that they can become a part of the meta-analysis in the future.

Effect of SC supplementation on mortality of growing rabbits.

The meta-analysis showed that SC supplementation to the diet of growing rabbits caused a significantly lower mortality during the experiment in comparison with the control groups: ES= -0.48 (-0.71; -0.24, p < 0.001). According to the obtained data, the middle level of heterogeneity between studies is ($I^2 = 52\%$). The results of the Q-test (Q=17.8) and its p-level (p=0.001) indicate no statistically significant heterogeneity and the null hypothesis which states that all studies share a common effect size is confirmed (Fig.7).

Own studies

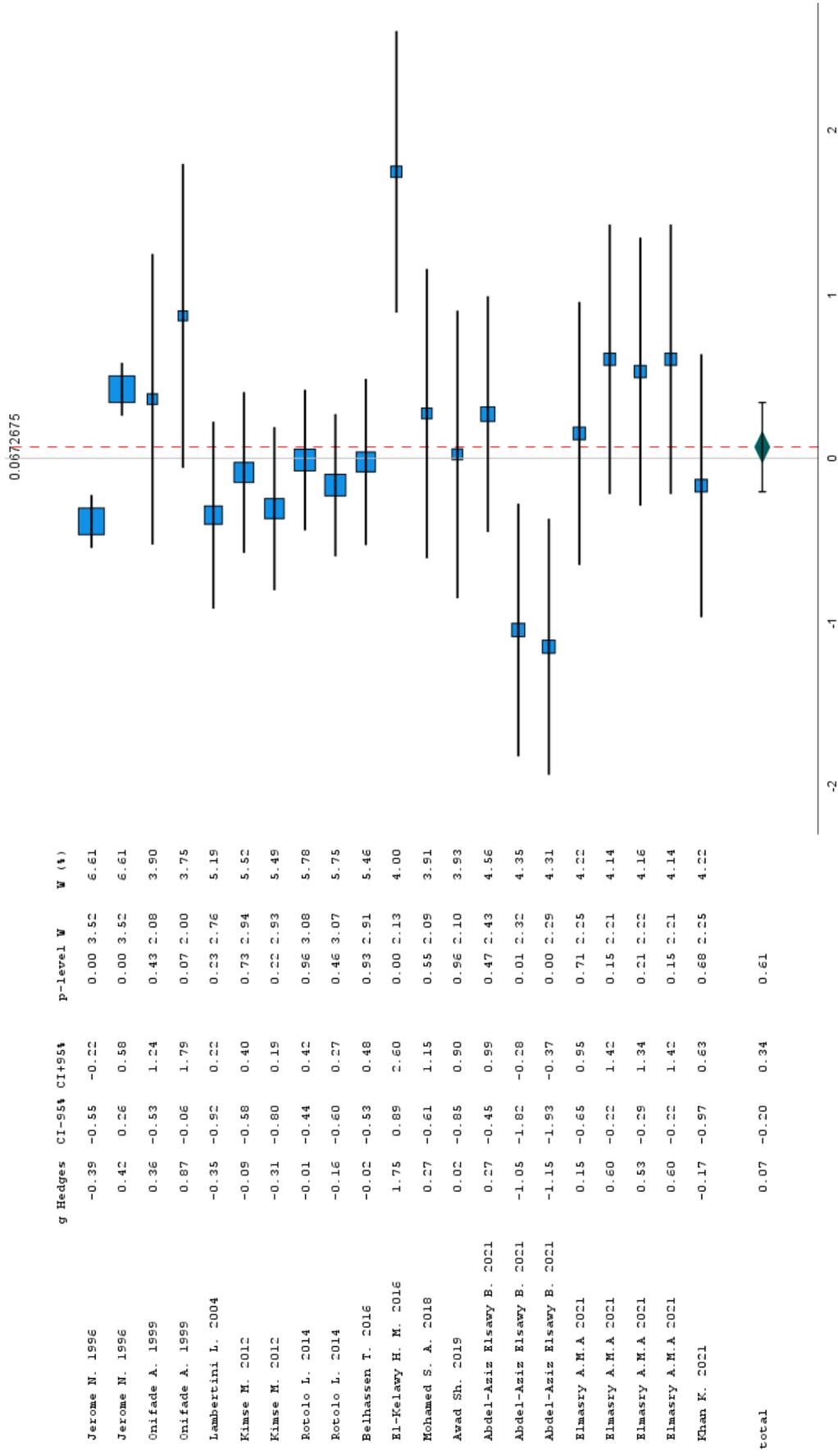
The average weight of rabbits in the control and experimental groups did not have significant differences at the beginning of the experiment. After 37 days of fattening, the control group reached an average weight of 2 kg 230 g, whereas the weight for the experimental group was 2.608 kg, probably due to the better FCR in the experimental group. Both mentioned differences were significant. Whereas the daily feed intake did not differ in the studied groups (Table 5).

Table 5

Weight, feed intake and feed conversion ratio observed during the study in control and experimental groups

Parameters	Control group		Experimental group		significance of difference
	Mean	SD	Mean	SD	
Start weight, kg	0.97	0.06	0.96	0.05	$F_{(1, 198)} = 2.16$, p=0.143
Final weight, kg	2.23	0.11	2.30	0.09	$F_{(1, 188)} = 27.80$, p<0.001
Feed intake (g/day) ¹	123.66	8.19	122.94	5.88	$F_{(1, 38)}=0.1$, p=0.75
FCR	3.84	0.47	3.45	0.31	$F_{(1, 38)}=9.54$, p=0.0038
Average daily gain, g ¹	33.98	3.14	36.36	2.83	$F_{(1, 188)}=30.03$, p<0.001

Comparison of the rabbit survival in each group showed no significant difference for the one-sided t-criterion (p=0.097).



Criteria for total effect size: $t = 0.52$, $df = 20$, $p\text{-level} = 0.61$

Fig. 6 - Forest plot for the result of meta-analysis (feed intake, g/day)

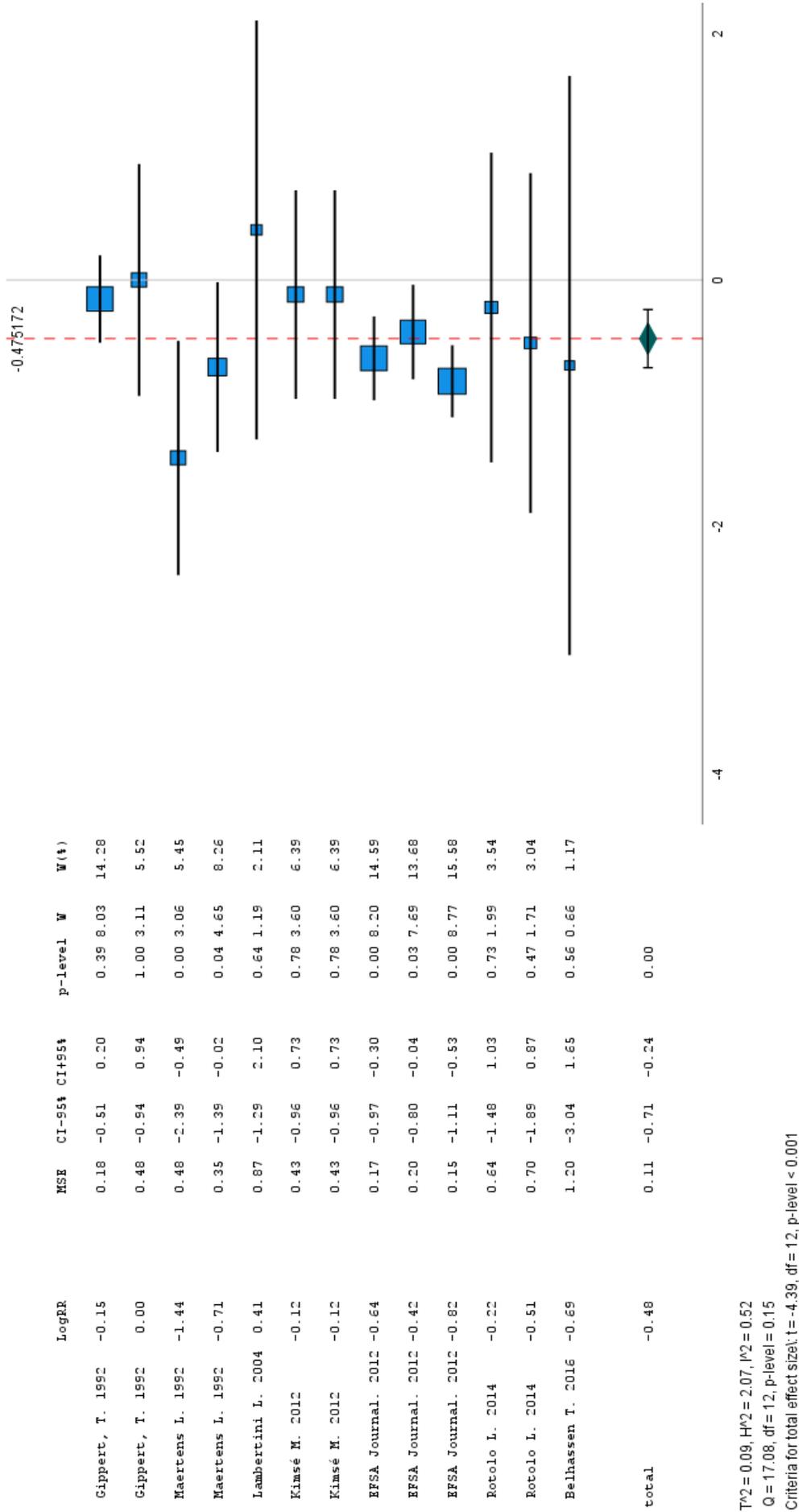


Fig. 7 - Forest plot for the result of meta-analysis (mortality)



The usage of feed with SC additive affects the results conceding rabbits fattening. Experimental group obtained the statistically significant best average final weight, daily gain and feed conversion ratio in the same raising conditions. It confirms the results obtained from the meta-analysis. At the same time, there is no statistically proven change in feed intake between groups, and that is a promising and important economic and ecological result.

Our average daily gain was not as high as it had been published by other authors: 44.34-45.54 g/day [25]. However, it is similar to the data obtained by the conducted experiments in the conditions of an industrial farm (32.3 - 32.7 g/day [12], 27-37 g/day [19] and 25.53-33.15 g/day [Ошибка! Источник ссылки не найден.]).

The overall mortality in the control group was 7%, an acceptable value for the considered period of productive age. The overall mortality in the experimental group was lower (3%), but there is no statistically proven change.

Conclusions.

In a pooled analysis, supplementation of *Saccharomyces cerevisiae* to the diet of growing rabbits caused a significant increase in final weight by 132.24 g. The effect of *Saccharomyces cerevisiae* administration was not characterized by statistically significant variation in the genetic subgroups of rabbits (test for subgroup differences: $p = 0.759$). In parallel there was a statistically significant variation in subgroups of SC dose (test for subgroup differences: $p=0.04$). When a higher concentration of *Saccharomyces cerevisiae* was used, the average final weight in the experimental group was 209.23 g higher than the final weight in the control group. When a lower concentration of SC was used, the average final weight in experiment was more than the control by 93.38 g.

In later publications, the difference in weight between the experimental and control groups has improved markedly. We cannot say for sure yet whether it is the evolution of the commercial *Saccharomyces cerevisiae* strains, the genetic improvement of industrial breeds and hybrids of rabbits or modernization of housing and feeding technology. It is more likely to be the result of the combined effect of these factors. Also the same situation there is its relation to the improvement of feed conversion ratio.

In own researches after 37 days of fattening, the control group reached an average weight of 2 kg 230 g, whereas the weight for the experimental group was 2.608 kg, probably due to the better FCR in the experimental group. Both mentioned differences were significant. Whereas the daily feed intake did not differ in the studied groups. Comparison of the rabbit survival in each group showed no significant difference for the one-sided t-criterion ($p=0.097$).

Therefore, the usage of feed with *Saccharomyces cerevisiae* additive affects the results conceding rabbits fattening. Experimental group obtained the statistically significant best average final weight, daily gain and feed conversion ratio in the same raising conditions. It confirms the results obtained from the meta-analysis. At the same time, there is no statistically proven change in feed intake between groups, and that is a promising and important economic and ecological result.

References

1. Wang, H.; Long, W.; Chadwick, D.; Zhang, X.; Zhang, S.; Piao, X.; & Hou, Y. (2022). Dietary Acidifiers as an Alternative to Antibiotics for Promoting Pig Growth Performance: A Systematic Review and Meta-Analysis. *Animal Feed Science and Technology*, 289, 115320. <https://doi.org/10.1016/j.anifeedsci.2022.115320>.



2. Carabaño, R., Badiola, I., Licois, D., & Gidenne, T. (2006). The Digestive Ecosystem and Its Control through Nutritional or Feeding Strategies. In: Maertens L., Coudert P., editors. *Recent Advances in Rabbit Sciences*. Melle, Belgium, 211–227.
3. Vilà, B., Esteve-Garcia, E., & Brufau, J. (2010). Probiotic Micro-Organisms: 100 Years of Innovation and Efficacy; Modes of Action. *World's Poult. Sci. J.*, 66, 369–380. <https://doi.org/10.1017/S0043933910000474>.
4. Havenaar, R., ten Brink, B., & Huis, J. H. J. (1992). *Probiotics*. Springer; Berlin/Heidelberg, Germany: Selection of Strains for Probiotic Use, 209–224.
5. Misiukiewicz, A., Gao, M., Filipiak, W., Cieslak, A., Patra, A. K., & Szumacher-Strabel, M. (2021). Review: Methanogens and methane production in the digestive systems of nonruminant farm animals. *Animal*, 15(1), 100060. <https://doi.org/10.1016/j.animal.2020.100060>
6. Chaudhary, L. C., Singh, R., Kamra, D. N., & Pathak, N. N. (1995). Effect of oral administration of yeast (*Saccharomyces Cerevisiae*) on digestibility and growth performance of rabbits fed diets of different fibre content. *World Rabbit Science*, 3(1), 15-18. <https://doi.org/10.4995/wrs.1995.235>
7. Korkh, O. V., Platonova, N. P., Aksonov, Ie. O., Petrash, V. S., & Smetana, O. I. (2021). Pokaznyky miasnoi produktyvnosti vidhodivelnoho molodniaku kroliv za vykorystannia probiotyka [Indicators of meat productivity of fattening young rabbits using probiotics]. *Naukovo-tehnichnyi biuleten Instytutu tvarynnytstva NAAN – Scientific and Technical Bulletin of the Institute of Animal Science of the National Academy of Agrarian Science of Ukraine*. Kharkiv, 126, 52–61. <https://doi.org/10.32900/2312-8402-2021-126-52-62> [in Ukrainian]. <http://animal.kharkov.ua/index.php/component/content/article/2-uncategorised/640-ntb126-8>
8. Gidenne, T., & Maertens, L. (2016). Feed efficiency in rabbit production: Nutritional, technico-economical and environmental aspects. In: 11. World Rabbit Congress. Proceedings World Rabbit Congress. WRSA. Accessed July 15. <https://hal.archives-ouvertes.fr/hal-02046863>.
9. Higgins, J. P. T, Thomas, J., Chandler, J., Cumpston, M., Li, T., Page, M.J., & Welch, V. A. (editors) (2022). *Cochrane Handbook for Systematic Reviews of Interventions* version 6.3 (updated February 2022). Cochrane. Available from www.training.cochrane.org/handbook.
10. Jerome, N., Mousset, J. L., Lebas, F., & Robart, P. (1996). Effect of diet supplementation with oxytetracycline combined or not with different feed-additives on fattening performance in the rabbit. 6th World Rabbit Congress, Toulouse, France, 9-12/07/1996. 1. 205-210.
11. Onifade, A. A., Obiyan, R. I., Onipede, E., Adejumo, D. O., Abu, O. A., & Babatunde, G. M. (1999). Assessment of the effects of supplementing rabbit diets with a culture of *Saccharomyces cerevisiae* using growth performance, blood composition and clinical enzyme activities. *Animal Feed Science and Technology*, 77(1-2), 25-32. [https://doi.org/10.1016/S0377-8401\(98\)00244-2](https://doi.org/10.1016/S0377-8401(98)00244-2)
12. Lambertini, L., Vignola, G., Beone, G. M., Zaghini, G., & Formigoni, A. (2004). Effects of chromium yeast supplementation on growth performances and meat quality in rabbits. *World Rabbit Science*, 12(1), 33-47. <https://doi.org/10.4995/wrs.2004.582>
13. Kimsé, M., Bayourthe, C., Monteils, V., et al. (2012). Live yeast stability in rabbit digestive tract: Consequences on the caecal ecosystem, digestion, growth and digestive health. *Animal Feed Science and Technology*, 173, 235-243. <https://doi.org/10.1016/j.anifeedsci.2012.01.012>



14. Rotolo, L., Gai, F., Peiretti, P. G., Ortoffi, M., Zoccarato, I., & Gasco, L. (2014). Live yeast (*Saccharomyces cerevisiae* var. *boulardii*) supplementation in fattening rabbit diet: Effect on productive performance and meat quality. *Livestock Science*, 162, 178-184. <https://doi.org/10.1016/j.livsci.2014.01.022>
15. Belhassen, T., Bonai, A., Gerencsér, Z., et al. (2016). Effect of diet supplementation with live yeast *Saccharomyces cerevisiae* on growth performance, caecal ecosystem and health of growing rabbits. *World Rabbit Science*, 24 (3), 191-200. <https://doi.org/10.4995/wrs.2016.3991>
16. El-Kelawy, H., & El-Kelawy, M. (2016). Impact of dietary supplementation with multi enzyme and/or probiotic on growth performance, nutrients digestibility and blood constituents of growing rabbits. *Egyptian Journal of Nutrition and Feeds*, 19(2), 313-323. <https://doi.org/10.21608/ejnf.2016.74913>
17. Ayyat, M. S., Al-Sagheer, A. A., Abd, El-Latif, K. M., & Khalil, B. A. (2018). Organic Selenium, Probiotics, and Prebiotics Effects on Growth, Blood Biochemistry, and Carcass Traits of Growing Rabbits During Summer and Winter Seasons. *Biol Trace Elem Res.*, 186(1), 162-173. <https://doi.org/10.1007/s12011-018-1293-2>
18. Awad, A., Abd Elhamid, A. E., Azoz, A. B., & Elthawy, W. (2019). Effect of addition of *Saccharomyces cerevisiae* and/ or sodium butyrate on growth performance and blood biochemicals in growing rabbits. *Egyptian Journal of Rabbit Science.*, 29 (2), 171-195. <https://doi.org/10.21608/ejrs.2019.84223>
19. Abdel-Aziz Elsayy, B., Ahmed, A., Elbadwy, Y., & Elsyed, I. (2021). Impact of *Saccharomyces Cerevisiae Boulardii* Supplementation as Probiotic on Productive Performance and Economic Efficiency of Growing Rabbits. *Arab Universities Journal of Agricultural Sciences*, 29(2), 795-800. <https://doi.org/10.21608/ajs.2021.52876.1308>
20. Elmasry, A. M. A, Miranda, L. A., Mendoza, G., & Plata, F. X. (2021). Effect of Yeast Type and Dose on Growth Performance and Nutrient Digestibility of Growing Rabbits Fed Maize or Barley. *Indian Journal of Animal Research.* <https://doi.org/10.18805/IJAR.B-1331>
21. Khan, K., Aziz, K., Khan, N. A., Khan, S., & Ayasan, T. (2022). Effect of enzyme and yeast-based feed additives on growth, nutrient digestibility, meat quality and intestinal morphology of fattening rabbits. *Journal of the Hellenic Veterinary Medical Society*, 72, 3511-3518. <https://doi.org/10.12681/jhvms.29404>
22. EFSA (European Food Safety Authority) (2005). The Impact of the current housing and husbandry systems on the health and welfare of farmed domestic rabbits. *EFSA Journal*, 267, 1–31. <https://doi.org/10.2903/j.efsa.2005.267>
23. Gidenne, T., Garreau, H., Drouilhet, L., Aubert, C., & Maertens, L. (2017). Improving feed efficiency in rabbit production, a review on nutritional, technico-economical, genetic and environmental aspects. *Animal Feed Science and Technology*, 225, 109-122.
24. Maertens, L., & Gidenne, T. (2016). Feed efficiency in rabbit production: nutritional, technico-economical and environmental aspects. 11th World Rabbit Congress-June 15-18,2016-Qingdao-China, 337-352.
25. Maj, D., Bieniek, J., Łapa, P., Sternstein, I. (2009). The effect of crossing New Zealand White with Californian rabbits on growth and slaughter traits. *Archiv Tierzucht.* 52. 205-211. <https://doi.org/10.5194/aab-52-205-2009>.
26. Maertens L., De Groote G. (1992). Effect of a dietary supplementation of live yeast on the zootechnical performancfs of does and weanling rabbits Proceedings 5th World Rabbit Congress, 25-30 July 1992, Corvallis – USA, 1079-1086.



МЕТА-АНАЛІЗ ВПЛИВУ ДІЄТИЧНОЇ ДОБАВКИ *SACCHAROMYCES CEREVISIAE* MUGL 39885 НА ВІДГОДІВЛЕНУ ПРОДУКТИВНІСТЬ ПРОМИСЛОВИХ КРОЛІВ

Платонова Н. П., доктор с.-г. наук, Інститут тваринництва НААН / Університет Адама Міцкевича у Познані, Польща

Проведено дослідження з визначення впливу добавки *Saccharomyces cerevisiae* MUGL 39885 у раціоні відгодівельного молодняка кролів на їхню виживаність, показники продуктивності та коефіцієнт конверсії корму.

У мета-аналізі додавання *Saccharomyces cerevisiae* MUGL 39885 до раціону відгодівельних кролів викликало значне збільшення кінцевої ваги на 132,24 г (не-стандартизована середня різниця). Згідно з отриманими даними, існує систематична помилка, пов'язана з упередженням публікацій (критерій Еггера, $p = < 0,001$) і високою неоднорідністю між дослідженнями ($I^2 = 92,9\%$, $p < 0,001$). Результати Q -тесту ($\chi^2 = 282,733$, $p < 0,001$) вказують на наявність статистично значущої неоднорідності, а нульову гіпотезу, яка стверджує, що всі дослідження мають спільний розмір ефекту, було відхилено. Ефект введення *Saccharomyces cerevisiae* не характеризувався статистично значущими варіаціями в генетичних підгрупах кролів (тест на підгрупові відмінності: $p = 0,759$). Паралельно існує статистично значуща варіація в підгрупах дози введення (тест на відмінності підгруп: $p = 0,04$). За застосування вищої концентрації *Saccharomyces cerevisiae* середня кінцева маса в дослідній групі була на 209,23 г вищою, ніж в контрольній групі. При меншій концентрації *Saccharomyces cerevisiae* середня кінцева маса в досліді була більшою за контроль на 93,38 г.

Saccharomyces cerevisiae (MUGL 39885, 0,01% - 15 мільярдів клітин на грам) додавали в корм для дослідної групи кролів ($n = 200$) перед гранулюванням. За 37 днів відгодівлі контрольна група досягла середньої маси 2230 г, тоді як маса дослідної групи становила 2608 г, ймовірно, завдяки кращому FCR. Порівняння виживаності кролів у кожній групі не показало суттєвої різниці для однобічного t -критерію ($p = 0,097$).

Отже, використання комбікорму з добавкою *Saccharomyces cerevisiae* впливає на результати відгодівлі кролів. Дослідна група отримала статистично значущу найкращу середню кінцеву масу, добовий приріст і коефіцієнт конверсії корму в однакових умовах вирощування. Це підтверджує результати мета-аналізу. У той же час, немає статистично підтверджених змін у споживанні корму між групами, і це багатообіцяючий і важливий економічний та екологічний результат.

Ключові слова: відгодівля кролів, *Saccharomyces cerevisiae*, м'ясна продуктивність, коефіцієнт конверсії корму, мета-аналіз.