Comparing Saudi synthetic lines of rabbits with the founder breeds for carcass, lean composition and meat quality traits

A M Al-Saef, M H Khalil, S N Al-Dobaib, A H Al-Homidan, M L García and M Baselga**

Department of Animal Production and Breeding, College of Agriculture and Veterinary Medicine, Al-Qassim University, Buriedah 51452 P.O.Box 6622, Saudi Arabia
**División de Producción Animal, Departamento de Tecnología Agroalimentaria, Universidad Miguel Hernández, Ctra Beniel Km. 3.2 Orihuela 03312, Alicante Spain*
***Departamento de Ciencia Animal, Universidad Politecnica de Valencia, Camino de Vera 14, Apdo 22012, 46071, Spain*
maherhkhalil@yahoo.com

Abstract

An evaluation for five-year crossbreeding project was performed for pre-slaughter weight (PSW), weights of hot carcass (HCW) and offal (OW) as edible carcass, dressing percentages (DP), weights of head (HW), fur (FURW), lung (LW) and viscera (VW) as non-edible carcass traits, weights of meat (MW), bone (BW) and fat (FW) as tissues composition and percentages of dry matter (DM), crude protein (CP), ether extract (EE) and ash in the lean as meat quality traits. This crossing project involving a Spanish maternal line called V-line (V) and a Saudi Gabali (S) rabbits and 14 genetic groups of V, S, ½V½S, ½S½V, ¾V¼S, ¾S¼V, $(½V½S)^2$, $(½S½V)^2$, $(¾V¼S)^2$, $(¾S¼V)^2$, $((¾V¼S)^2)^2$, $((¾S¼V)^2)^2$, Saudi 2 (synthesized maternal line), and Saudi 3 (synthesized paternal line) were produced in this project. A total number of 2770 rabbits fathered by 91 sires and mothered by 402 dams were slaughtered. Heritability and common litter effects were estimated using an animal model and solutions of the mixed model equations for the genetic group effects were estimated to identify the possibilities of using Saudi 2 and Saudi 3 as synthetic lines in hot climate areas.

Heritability estimates were mostly moderate and ranging from 0.17 to 0.22 for edible carcass traits, 0.12 to 0.22 for non-edible carcass traits, 0.14 to 0.20 for lean composition traits, and 0.12 to 0.36 for meat quality traits. For common litter effects, the estimates were mostly moderate or high and ranging from 0.31 to 0.35, 0.29 to 0.39, 0.15 to 0.29, and 0.17 to 0.23, respectively. Relative to line V or Saudi Gabali, Saudi 2 (with ¾ of its genes coming from line V) and Saudi 3 (with only ¼ of its genes coming from line V) were mostly significantly superior in PSW, edible carcass (HCW, OW), DP, non-edible carcass (HW, LW, VW), tissues composition (MW, BW), MBR, and meat quality traits (DM, EE and ash). In most cases, the estimates for Saudi 2 were found to be significant ranging from 5.3 to 17.0% for slaughter and edible carcass traits, from 9.7 to 18.1% for non-edible carcass traits, 7.5 to 15.1% for tissues compositions, and 3.8 to 39.2 % for meat quality traits comparable to purebred Saudi rabbits, while the estimates for Saudi 3 ranged from 8.6 to 18.6%, 11.7 to 18.8%, 8.5 to 13.9%, and 3.2 to 47.1%, respectively.

In practice, both Saudi 2 and Saudi 3 could be used as specialized synthetic lines convenient for hot climate countries since they were significantly superior in carcass performance, lean composition and meat quality traits relative to the founder lines.

Key words: animal model, carcass, common litter effects, heritability, meat quality, rabbits, synthetic lines

Introduction

Genetic improvement strategies could considerably increase growth and meatiness in the rabbits (Pla et al 1998; Piles et al 2000). In fact, current selection programmes in most parts of the world are selecting for fast growth rates and use of terminal sires, with the goals to improve growth and carcass efficiency (Feki et al 1994; Lobera et al 2000; Sánchez et al 2004). In developed countries, using crossbred terminal sires for growth and carcass traits is necessary to synthesize new paternal lines (Masoero et al 1985, 1992; Pla et al 1998; Piles et al 2000). In developing countries and in hot climate countries in particular, reports of genetic analyses for carcass traits and meat quality are unfortunately scarce.

At the beginning of this decade (2000), a co-operative rabbit project was established between Saudi Arabia and Spain to synthesize new lines of rabbits adaptable for hot climate. Some traits in this project such as litter, lactation, feeding and semen traits have been genetically evaluated (Khalil et al 2004; Khalil et al 2005), while others such as carcass and meat quality traits have not. The objectives of the present study were (1) to estimate heritabilities, common litter effects and random error effects for carcass and meat quality traits in a crossbreeding program involving one Saudi breed and one Spanish line of rabbits, that are the founders of the new lines, and (2) to evaluate carcass performance and meat quality of the two new maternal and paternal lines of rabbits synthesized. These synthetic lines have now reached the 7th generation of selection for litter weight at weaning and individual weight at 84 d using a BLUP methodology under an animal model.

Materials and methods

Crossbreeding plan and management

A five-year crossbreeding project was started in September 2000 in the Experimental Rabbitry, College of Agriculture and Veterinary Medicine, Qassim University to develop new maternal and paternal lines of rabbits. Rabbits used in this project represent one desert Saudi Gabali breed (S) and one exotic Spanish breed (V-line). The Spanish V-line rabbits used in this project were imported from Valencia Polytechnic University in Spain to be crossed with Saudi Gabali rabbits. Such maternal V-line was selected in Spain for number of young weaned per litter since 1984 using BLUP with a repeatability animal model and non-overlapping generations (Estany et al 1989). Details of the procedures and crossbreeding plan used in the project to form these synthetic lines were described by Khalil et al (2005, 2007). The crossbreeding plan permitted simultaneous production of 14 genetic groups as shown in Table 1.

The rabbits were managed with natural mating in a semi-closed rabbitry. In the rabbitry, the environmental conditions were monitored; temperature ranged from 20 to about 32°C, relative humidity ranged from 20 to 50%, and the photoperiod in hours was 16 h light: 8 h dark. At four weeks of age, young rabbits were weaned, ear tagged, weighed, sexed and reared in progeny wire cages equipped with feeding hoppers and drinking nipples. Rabbits were fed a commercial pelleted diet during the whole period. On a dry matter basis, the commercial pelleted diet contained 17.9% crude protein, 15.57% crude fiber, 2.45% ether extract, 58.5 nitrogen free extract, and 6.29% ash.

Data set

Data used in this study were recorded from November 2000 until July 2005. At 12 weeks of age, rabbits representing 14 genetic groups were randomly slaughtered to obtain carcass traits. A total of 2770 rabbits from 91 sires and 402 dams were slaughtered. The numbers of rabbits slaughtered from each genetic group are presented in Table 1. According to criteria and terminology for carcass traits and lean composition cited by Blasco et al (1993), rabbits were dissected for edible parts and non-edible ones. Hot carcasses were weighed and dressing percentages were calculated. The head, fur, offal (representing heart + liver + kidneys) and viscera of the carcasses were also weighed. For lean composition traits, all carcasses were divided longitudinally into two similar halves. The right half was separated into lean, fat and bone. Lean of each half was separated and prepared for chemical analysis. Dry matter (using an air-evacuated oven for 16 h), crude protein (Nitrogen x 6.25), ether extract and ash in the lean were determined according to the AOAC (1990).

Table 1. Genetic groups of the rabbits slaughtered and their sires, dams, and numbers slaughtered at 12 weeks of age for each genetic group

Ordinal number	Rabbit genetic group	Sire genetic group	Dam genetic group	Grand-dam group	Rabbits slaughtered	Rabbits chemically analyzed
1	V-line (V)	V-Line	V-Line	V	276	234
2	Saudi (S)	Saudi (S)	Saudi (S)	S	275	232
3	½V½S	V	S	S	223	203
4	½S½V	S	V	V	260	216
5	¾V¼S	V	½S½V	V	141	129
6	¾S¼V	S	½V½S	S	204	158
7	$(½V½S)^2$	½V½S	½V½S	S	113	111
8	$(½S½V)^2$	½S½V	½S½V	V	157	145
9	$(¾V¼S)^2$	¾V¼S	¾V¼S	½S½V	173	155
10	$(¾S¼V)^2$	¾S¼V	¾S¼V	½V½S	202	198
11	$((¾V¼S)^2)^2$	$(¾V¼S)^2$	$(¾V¼S)^2$	¾V¼S	197	189
12	$((¾S¼V)^2)^2$	$(¾S¼V)^2$	$(¾S¼V)^2$	¾S¼V	145	137
13	Saudi 2	$((¾V¼S)^2)^2$	$((¾V¼S)^2)^2$	$(¾V¼S)^2$	123	122
14	Saudi 3	$((¾S¼V)^2)^2$	$((¾S¼V)^2)^2$	$(¾S¼V)^2$	281	224
Total					**2770**	**2453**

Model for analysis

The animal model (in matrix notation) used for analysing carcass and meat quality traits was:

$$y= Xb + Z_a u_a + Z_c u_c + e$$

Where:

y = vector of measurements for the slaughtered rabbits,
b = vector of fixed effects of genetic group of slaughtered rabbits (14 levels; see Table 1), and year-season of birth (20 levels), sex, parity order of the doe (5 levels), and litter size in which the rabbits were born (9 levels);
u_a = vector of random additive effect of the individual rabbit,
u_c = vector of random effects of the litters in which the animal was born;
X, Z_a and Z_c are incidence matrices relating the records to the fixed effects, additive genetic effects, and common litter environmental effects, respectively; and
e is a vector of random residual effects.

Variance components of the random effects were estimated by a derivate-free restricted maximum likelihood procedure using MTDFREML software of Boldman et al (1995). Local convergence was considered to be met if the variance of the -2 log likelihoods in the simplex was less than $1x10^{-6}$. After first convergence, restarts were made to find global convergence with convergence declared when the values of -2 log likelihood did not change to the second decimal. The inverse of the numerator relationship matrix (A^{-1}) was used with:

The variance components obtained by the Animal Model were used to solve the corresponding mixed model equations, obtaining solutions for the genetic group means and their standard errors, using the PEST program (Groeneveld 2006).

Results and discussion

Actual means and variations

Results in Table 2 describe the performance of carcass and meat quality traits for rabbits raised in this project.

Table 2. Summary statistics for carcass and meat quality traits

Trait		Mean	Standard deviation	Minimum	Maximum
Item	**Abbreviation**				
Pre-slaughter weight, *g*	PSW	2482	306	1442	3390
Edible carcass traits:					
Hot carcass weight, g	HCW	1381	201	709	2024
Dressing percent, %	DP	55.5	2.9	40.9	65.0

Offal weight, g	OW	100.1	22.2	54.0	209
Non-edible carcass traits:					
Head weight, g	HW	224	25	122	293
Fur weight, g	FW	236	42	113	349
Lung weight, g	LW	104	15	60	192
Viscera weight, g	VW	398	67	100	593
Tissues composition in the carcass:					
Meat weight, g	MW	1041	153	550	1496
Bone weight, g	BW	271	59	112	518
Fat weight, g	FW	28.9	16.1	1.9	93.3
Meat to bone ratio	MBR	3.98	0.87	2.3	9.1
Meat quality traits:					
Dry matter, %	DM	28.7	1.9	22.3	36.0
Crude protein, %++	CP	76.1	5.8	46.9	91.2
Ether extract, %++	EE	15.0	5.9	1.1	49.9
Ash, %++	Ash	9.0	4.1	1.3	18.2

+*Dressing percentages = (HCW/PSW)x100.; Traits expressed on dry matter basis.*

Slaughter weight of the rabbits of this experiment ranged from 1442 to 3390 g with an average of 2482 g, while hot carcass weight ranged from 709 to 2024 *g* with an average of 1381 *g* (Table 2). Estimates revised by Colin (1999) indicate that carcass weights are varied from one country or region to another to be ranged from 1.0 to 1.8 kg. Ozimba and Lukefahr (1991) in USA observed a mean of 1.02 kg for hot carcass when rabbits were slaughtered at 2.02 kg. For hot carcass weight of New Zealand White rabbits raised in Egypt, Ayyat et al (1994) and Marais et al (1996) reported lower value of 1291 and 1150 g, respectively.

The dressing out percentage averaged 55.5 % across all genetic groups (Table 2). This percentage is comparable to Afifi et al (1994) in Egypt for rabbits slaughtered at 12 weeks of age, while Ozimba and Lukefahr (1991) in USA and Feki et al (1994) and Lobera et al (2000) in Spain obtained higher values for dressing out percentages in rabbits slaughtered at 71 or 63 days of age. These variations may be attributed to that breeds and times of slaughter used in each experiment were different, the change in allometric coefficients and the carcass yield seems to be increased until 91 days (Dalle Zotte and Ouhayoun 1995). Szendrö et al (1996) in Hungary found that the best dressing percentages were obtained from rabbits weighted in the range from 3.2 to 3.4 kg.

Meatiness expressed as meat bone ratio was 3.98 (Table 2). Szendrö et al (1996) in Hungary found that the best ratios of meatiness were obtained from rabbits weighted in the range from 3.2 to 3.4 kg. Pla et al (1998) found that meat-bone ratio of V line was 4.56 when the rabbits were slaughtered at nine weeks of age.

Fatness expressed as percentage of dissectible fat (28.9g) across all genetic groups was found to be 2.1 % relative to the hot carcass weight (Table 2). For fatness, Feki et al (1994) in Spain reported values of 15.9 and 5.3 g of perirenal fat weight and scapular fat weight for V line rabbits slaughtered at an average weight of 2033 g. Blasco and Ouhayoun (1993) indicated that the percentage of dissectible fat ranged from 3 to 6% of the carcass.

Data corresponding to meat quality traits are described in Table 2. A total of 2453 rabbits were dissected to be chemically analysed. On dry matter basis, figures of meat quality gave an impression to that rabbit meat could be appreciated for its high nutritional and dietetic properties since ether extract in the lean was low (15.0%) and protein content was high (76.1%) as shown in Table 2. Pla et al (1998) chemically analysed four carcass portions in V-line rabbits and found that fat percent in foreleg, *Longissimus dorsi*, abdominal wall, and hind leg was 6.89%, 0.90%, 5.66% and 3.45%, respectively, but the slaughter weight in their study was lower than here, while the protein was always lower than the values in our study; no matter the carcass portions. However, Parigi Bini et al (1992) reported that meat rabbit are high in unsaturated lipids (60%), high in amino acids of high biological values, poor in cholesterol and sodium, and rich in potassium, phosphorous and magnesium.

Heritability estimates

Heritability estimates for edible and non-edible carcass, lean composition and meat quality traits were mostly moderate (Table 3). The estimates ranged from 0.15 to 0.22 for slaughter and edible carcass traits, from 0.12 to 0.22 for non-edible carcass traits, from 0.14 to 0.20 for carcass compositions traits, and from 0.12 to 0.36 for meat quality traits. Heritabilities estimated by Ayyat et al (1994) for non-edible carcass traits for NZW rabbits raised in Egypt were low to moderate. In Brazil, Ferraz and Eler (1996) reported moderate estimates of heritability for carcass weight and carcass yield of 0.178 and 0.152 for the Californian breed and 0.152 and 0.000 for New Zealand White rabbits, respectively. Heritability estimated by Lukefahr et al (1996) in USA for carcass yield and lean-to-bone ratio were 0.37 and 0.35 for rabbits selected for 70-day body weight.

Table 3. Estimates of the proportion of the phenotypic variance due to additive genetic effects (h^2) and to common litter effects (c^2) and to random error effects (e^2) with standard errors (±SE) for carcass and meat quality traits

Trait	**h^2±SE**	**c^2±SE**	**e^2±SE**
PSW	0.15±0.060	0.37±0.035	0.48±0.044
Edible carcass traits:			
HCW	0.22±0.069	0.32±0.036	0.46±0.049
DP	0.17±0.078	0.35±0.036	0.48±0.055
OW	0.17±0.069	0.31±0.037	0.52±0.049
Non-edible carcass traits:			
HW	0.22±0.068	0.34±0.037	0.44±0.048
FURW	0.12±0.060	0.31±0.034	0.57±0.045
LW	0.13±0.051	0.39±0.033	0.48±0.038
VW	0.22±0.071	0.29±0.037	0.49±0.036
Carcass composition traits:			
MW	0.17±0.064	0.29±0.035	0.53±0.047
BW	0.19±0.066	0.21±0.033	0.60±0.049
FW	0.14±0.063	0.26±0.034	0.60±0.047
MBR	0.20±0.067	0.15±0.032	0.66±0.049
Meat quality traits, DM basis, %			

DM	0.36±0.084	0.21±0.040	0.43±0.059
CP	0.25±0.084	0.21±0.041	0.54±0.061
EE	0.12±0.070	0.23±0.037	0.65±0.052
ASH	0.13±0.029	0.17±0.025	0.70±0.012

Common litter effects

Estimates of common litter effects for carcass traits, carcass composition and meat quality traits were moderate to high and were always higher than the respective heritabilities (Table 3). The estimates ranged from 0.31 to 0.37 for slaughter and edible carcass traits, 0.29 to 0.39 for non-edible carcass traits, 0.15 to 0.29 for composition traits, and 0.17 to 0.23 for meat quality traits. Common litter effects appeared to have strong effects on growth even up to slaughtering time. However, estimates heritabilities and common litter effects for carcass and meat quality traits ($P<0.05$ or $P<0.01$; Tables 4 and 5) obtained in this study were generally smaller than estimates available in the literature (e.g. Ferraz et al 1992; Lukefahr et al 1996). Ferraz et al (1992) reported common environmental effects to be consistently more important than direct genetic effects for growth traits studied, but Lukefahr et al (1996) indicated that for each carcass trait investigated, the magnitudes of direct genetic and common environmental effects were similar.

Comparing line V with Saudi Gabali

Edible and non-edible carcass traits and lean composition produced from V-line rabbits were mostly better than from Saudi rabbits as V-line rabbits had significantly heavier PSW, HCW, OW, HW, FURW, LW, MW, BW, with the richest meat in DM and ash (Tables 4 and 5). The superiority for **V**-line rabbits was expected and reflect the superiority of this line for growth and survival (Estany et al 1989; Pla et al 1996; Garcia et al 2000a,b). These results suggest the necessity to identify the genetic effects for growth and carcass performances in Saudi rabbits taking into account the genetic association between carcass traits and growth performance.

Table 4. Estimates of differences of the effects of lines V, Saudi 2 (S2) and Saudi 3 (S3) relative to Saudi Gabali breed (S) for carcass and meat quality traits

Doe trait[+]	Line V *vs* Saudi (V-S)		Saudi 2 *vs* Saudi (S2-S)		Saudi 3 *vs* Saudi (S3 – S)	
	Estimate ± SE	**%[++]**	**Estimate ± SE**	**%[++]**	**Estimate ± SE**	**%[++]**
PSW	197±29*	7.9	300±48**	11.5	334±43**	12.7
Edible carcass traits:						
HCW	200±19**	14.0	251±45**	17.0	281±29**	18.6
DP	4.0±0.2**	7.0	3.0±0.6*	5.3	5.0±0.4**	8.6
OW	20±2.0**	18.1	8±2.7*	8.1	12±3.1*	11.7
Non-edible carcass traits:						
HW	18±2.4*	8.0	27±5.6*	11.5	29±3.6**	12.2
FURW	24±3.9*	10.0	32±5.4*	12.9	31±6.1*	12.6
LW	10±1.3*	9.5	21±3.1**	18.1	22±2.0**	18.8
VW	22±6.1ns	5.6	40±8.4*	9.7	49±9.2*	11.7
Tissues composition in the carcass:						

MW	118±14*	11.3	131±34*	12.4	149±22**	13.9
BW	28±5.2*	9.9	45±13.2*	15.1	36±8.4*	12.4
FW	-1.1±1.48ns	-4.4	2.1±3.67ns	7.5	2.4±2.34ns	8.5
MBR	-0.51±0.07*	-13.2	0.52±0.19*	12.0	0.48±0.12*	11.0
Meat quality traits, DM basis (%):						
DM	-2.8±0.45*	-11.6	2.2±0.25*	8.2	2.3±0.57*	8.6
CP	-4.0±3.0ns	-6.4	2.6±7.7ns	3.8	2.1±0.49ns	3.2
EE	-1.1±0.07ns	-7.5	-4.4±02**	-39.2	-5.0±0.12**	-47.1
Ash	-0.8±0.39*	-9.7	1.8±0.85**	16.6	1.3±0.55**	12.6

+See table 2; ++ Estimates expressed as percentages relative to Saudi breed
*NS= P>0.05; *= P<0.05; ** = P<0.01*

Table 5. Estimates of differences of the effects of Saudi 2 (S2) or Saudi 3 (S3) lines relative to line V and Saudi 3 relative to Saudi 2 for carcass and meat quality traits

Doe trait+	Saudi 2 *vs* line V (S2-V)		Saudi 3 *vs* line V (S3-V)		Saudi 3 *vs* Saudi 2 (S3-S2)	
	Estimate ± SE	**%++**	**Estimate ± SE**	**%++**	**Estimate ± SE**	**%**
PSW	103±19*	4.1	137±14*	5.5	34±5ns	1.4
Edible carcass traits:						
HCW	101±16*	7.1	81±10*	5.7	-20±16ns	1.4
DP	-1.5±0.3ns	-2.6	1.0±0.4ns	1.7	2.0±0.2ns	3.5
OW	-12±1.7*	-10.9	-8.0±1.1*	-7.3	4.0±0.8ns	4.1
Non-edible carcass traits:						
HW	9.0±2.8*	4.0	11.0±1.2ns	4.9	2.0±2.0ns	0.9
FURW	8.0±5.5ns	3.8	7.0±2.8ns	2.9	-1.0±3.3ns	0.4
LW	11±2.8*	10.5	12±0.7*	11.4	1.0±1.1ns	1.0
VW	18±4.4ns	4.6	27±3.0*	6.9	9.0±5.2ns	2.2
Tissues composition in the carcass:						
MW	13±10ns	1.2	31±18.0ns	3.0	18.0±12.0ns	1.7
BW	17±2.0*	6.0	8±5.2ns	2.8	-9.0±4.8ns	3.2
FW	3.2±1.0*	13.1	3.5±0.9*	14.2	0.3±1.34ns	1.2
MBR	1.03±0.08**	26.8	0.99±0.09**	25.8	0.04±0.07ns	1.0
Meat quality traits, DM basis (%:						
DM	5.0±0.92**	20.7	5.1±0.91**	21.2	0.1±0.95ns	0.4
CP	6.6±1.3*	10.7	6.1±1.2*	9.9	-0.5±1.9ns	-0.8
EE	-3.3±0.2**	-22.8	-3.9±1.1**	-26.9	-0.6±0.5ns	-4.1
Ash	2.6±0.42**	31.7	2.1±0.14**	25.6	-0.5±0.16ns	-6.1

+See table 2; ++ Estimates expressed as percentages relative to line V.
*NS= P>0.05; *= P<0.05; ** = P<0.01*

Comparing synthetic Saudi 2 and Saudi 3 lines with the founder breeds

In order to evaluate the results of the two lines synthesized (Saudi 2 and Saudi 3), a comparison between these lines and line V and Saudi Gabali was carried out. The results of tests of differences between them obtained from the solutions of the mixed model equations for genetic group effects have shown in Tables 4 and 5. These solutions were used to identify the possibilities of using these rabbits as synthetic lines or not. However, Saudi 2 and Saudi 3 were superior for the majority of edible and non-edible carcass traits, carcass composition and meat quality traits.

Results of the two synthetic lines developed in the present study have shown that Saudi 2 (with ¾ of its genes coming from line V) and Saudi 3 (with only ¼ of its genes coming from line V) were significantly superior in edible and non-edible carcass traits relative to line V or Saudi Gabali (Tables 4 and 5). Analyses of crossbreeding experiments carried out in the Arabian countries (*e.g.* Afifi et al 1994; El-Deghadi 2005) showed much less estimates in carcass traits than for the two synthetic lines developed here. Bianospino et al (2004a,b) in Brazil recommended that crossbred rabbits could be used to produce retail cuts and carcass because they would have heavier carcasses and loins without increased fatness. Metzger et al (2004b) in Hungary with Pannon White (P), Pannon Ka (PK), Hycole (H), Zika (Z) rabbits and their crossbreds reported that the most important carcass traits in P rabbits had an advantage.

Estimates for tissues composition in the carcass (MW, BW, FW, and MBR) were mostly in favour of Saudi 2 and Saudi 3 relative to the founder breeds (Tables 4and5). MBR was greater with earlier maturity and consequently synthetic rabbits had greater MBR than V-line rabbits (Pla et al 1996). Although the fat content of the carcass in rabbits is low relative to other animals, fat deposited in the carcass of the synthetic rabbits was greater than that in V-line rabbits (Table 5). However, fat deposits increases with age. Similar breed differences in fat deposited in the carcass have been found by Gomez et al (1998) and Metzger et al (2004a,b). Pla et al (1996) in Spain stated that R-line rabbits had fat percentages higher than line V. Metzger et al (2004a) in Hungary found that MBR in four genetic groups of Hyplus hybrid, Pannon White rabbits and their crossbreds were nearly similar (about 2.7). In another experiment in Hungary, Metzger et al (2004b) using Pannon White (P), Pannon Ka (PK), Hycole (H), Zika (Z) rabbits and their crossbreds reported significant differences among genetic groups for fat content of the carcass ($P<0.05$) were the early-maturing genetic groups were PK (1.8%) and P (1.8%).

Estimates for DM, CP, EE and ash contents in the lean were mostly in favour of synthetic lines relative to the founder breeds (Tables 4 and 5). In Hungary, Metzger et al (2004a) with four genetic groups found that differences in protein and ash contents of the lean.
The estimates for Saudi 2 relative to purebred Saudi rabbits were greatly deviated by values ranging from 5.3 to 17.0% for slaughter and edible carcass traits, from 9.7 to 18.1% for non-edible carcass traits, 7.5 to 15.1% for tissues compositions, and 3.8 to 39.2 % for meat quality traits ($P<0.05$ or $P<0.01$; Tables 4and5)). In comparison with purebred V-line, the corresponding estimates were slightly greater by 2.6 to 10.9 % for slaughter and edible carcass traits, by 3.8 to 10.5 % for non-edible carcass traits, by 1.2 to 26.8 % for carcass composition traits, and by 10.7 to 31.7 % for meat quality traits.

Comparing Saudi 3 with purebred Saudi rabbits, the estimates were widely deviated by differences ranging from 8.6 to 18.6 % for slaughter weight and edible carcass traits, 11.7 to 18.8 % for non-edible carcass traits, 8.5 to 13.9 % for carcass composition traits and 3.2 to 47.1 % for meat quality traits. Comparable to purebred V-line rabbits, the corresponding percentages ranged from 1.7 to 7.3 %, 2.9 to 11.4 %, 2.8 to 25.8 %, and 9.9 to 26.9 %.

Comparing Saudi 3 with Saudi 2, the estimates for both lines were nearly similar with no significant differences between them in all traits studied (Table 5).

Offal of the synthetic line rabbits was less in weight than V-line rabbits (Table 5). Liver and heart (offal) are organs of early development and animals with high growth rate have an earlier development (Gomez et al 1998). Gomez et al (1998) found that liver and heart weights for rabbits of line R were heavier than for line V. Results in the literature comparing breeds of large-size with small-size breeds and straightbreds with crossbreds for carcass traits are not consistent (Lukefahr et al 1982, 1983; Ozimba and Lukefahr 1991; Pla et al 1996; Bianospino et al 2004a,b) because measurements were made at different slaughter weights but differences can be partially due to true genetic differences between breeds.

Conclusions

- The use of an exotic line (line V), highly selected for litter size at weaning, and a local breed (Saudi Gabali), well adapted to hot climates, has led successfully to synthesize two new lines named Saudi 2 and Saudi 3.

- Both lines could be used in hot climates areas efficiently since they perform better than the founder lines for carcass traits, carcass composition and meat quality traits.

Acknowledgment

This project is supported by a grant (ARP: 18-62) from King Abdulaziz City for Science and Technology in Saudi Arabia.

References

Afifi E A, Khalil M H, Khadr A F and Youssef Y M K 1994 Heterosis, maternal and direct effects for post weaning growth traits and carcass performance in rabbit crosses. Journal of Animal Breeding and Genetics 111: 138-147

AOAC 1990 Official methods of analysis of the Association of Official Agricultural Chemists. Washington DC.

Ayyat MS, Anous M R and Sadek M H 1994 Genetic parameters for meat production in rabbits. 1. Non carcass components. World Rabbit Science 2(3): 93-99

Blasco A, Ouhayoun, J, and Masoero G 1993 Harmonization of criteria and terminology in rabbit meat research. World Rabbit Science 1(1):3-10

Bianospino E, Moura A S A M T, Wechsler F S, Fernandes S and Roca R O 2004a. Carcass and meat quality of straightbred and crossbred rabbits. 8th World Rabbit Congress, 7-10 September 2004, Puebla, Mexico, pp 1354-1359

Bianospino E, Wechsler F S, Moura A S A M T and Fernandes S 2004b. Growth traits and dressing percentage of straightbred and crossbred rabbits. 8th World Rabbit Congress, 7-10 September 2004, Puebla, Mexico, pp. 1360-1365

Blasco A, Ouhayoun J, and Masoero G 1993. Harmonization of criteria and terminology in rabbit meat research. World Rabbit Science 1(1):3-10

Boldmann K G, Kriese L A, Van Tassell C P, Kachman S D 1995. A manual for use of MTDFREML. A set programs to obtain estimates of variances and covariance [DRAFT]. U.S. Department of Agriculture, Agricultural Research Service, USA.

Colin M 1999 La cuniculture européenne. Cuniculture 150, 26(6): 2996301.

Dalle Zotte A and Ouhayoun J 1995. Post-weaning evolution of muscle energy metabolism and related physic-chemical traits in the rabbit. Meat Science 39: 395-401.

El-Deghady Amira S 2005 Genetic evaluation for some productive traits in rabbits. Ph.D. Thesis, Faculty of Agriculture, Banha University, Egypt

Estany J, Baselga M, Blasco A and Camacho J 1989 Mixed model methodology for the estimation of genetic response to selection in litter size of rabbits. Livestock Production Science 21:67-76

Feki S Gómez E A, Baselga M and Cifre J 1994 Differences in carcass composition in three rabbit lines selected for different traits. In: Proceedings of 5th World Genetic Congress Applied to Livestock Production. Guelph, Canada

Ferraz J B S and Eler J P 1996 Comparison of animal models for estimation of (co)variance components and genetic parameters of reproductive, growth and slaughter traits of Californian and New Zealand rabbits raised under tropical conditions. Proceedings of 6th World Rabbit Congress, Toulouse, France 2: 279-284.

Ferraz J B S , Johnson R K and Van Vleck, L D 1992 Estimation of genetic trends and genetic parameters for reproductive and growth traits of rabbits raised in subtropics with animal model. Journal of. Applied Rabbit Research 15:131-142

Garcia M L, Baselga M, Lavara R, Lavara F and Vicente J S 2000b. Reproductive characters in crossbreeding among three maternal lines of rabbits. 7th World Rabbit Congress, Valencia, Spain, Volume A: 397-402

Garcia M L, Blumetto O, Capra G, Vicente J S and Baselga M. 2000a Vitrified embryo of two selected Spanish rabbit lines to Uruguay. In: Proceedings 7th World Rabbit Congress, Valencia, Spain, 4-7 July 2000, World Rabbit Science 8 Supplement 1: 139-142.

Gomez E A , Baselga M, Rafel O, and Ramon J 1998 Comparison of carcass characteristics in five strains of meat rabbit selected on different traits. Livestock Production Science 55: 53-64

Groeneveld E 2006 " PEST user´s manual" , Institute of Animal Husbandry and Animal Behaviour, FAL, Germany

Khalil M H, Al-Sobayil K A, Al-Saef A M, García M L and Baselga M 2007 Genetic evaluation for semen characteristics and libido in a crossbreeding project involving Saudi and Spanish V-line rabbits. Animal, International Journal of Animal Bioscience 1 (7): 923-928

Khalil M, García M L, Al-Sobayil K A, Al-Homidan A H and Baselga M 2005 Genetic evaluation of crossbreeding project involving Saudi rabbits and Spanish V-line to synthesize new maternal lines in Saudi Arabia. I. Pre-weaning litter and lactation traits and feeding parameters. In: Proceedings of the 4th International Conference on Rabbit Production in Hot Climates. 24-27 February 2005. Sharm El-Sheikh. Egypt

Khalil M H, Mehaia M A, Al-Hodiman A H and Al-Sobayil K A 2004 Genetic analysis for milk yield and components and milk conversion ratio in crossing of Saudi rabbits with V-line. In: Proceedings of the 8th World Rabbit Congress, 7-10 September 2004, Puebla, Mexico, pp 82-89

Lobera J, Ruiz F, Ferrández F, Baselga M and Torres C 2000 Terminal sire and production of meat rabbit. In: Proceedings of 7th World Rabbit Congress, Valencia, Spain ,4-7 July 2000, Valencia, Spain, Volume A: 449-455

Lukefahr S D, Hohenboken W D, Cheeke P R and Patton N M 1983 Appraisal of nine genetic groups of rabbits for carcass and lean yield traits. Journal of Animal Science 57(4): 93-109 http://jas.fass.org/cgi/reprint/57/4/899.pdf

Lukefahr S, Hohenboken WD, Cheeke P R , Patton N M and Kennick W H 1982 Carcass and meat characteristics of Flemish Giant and New Zealand White purbred and terminal-cross rabbits. Journal of Animal Science 54:1169 http://jas.fass.org/cgi/reprint/54/6/1169.pdf

Lukefahr S D, Odi H B and Atakora J K A 1996 Mass selection for 70 day body weight in rabbits. Journal of Animal Science 74: 1481-1489 http://jas.fass.org/cgi/reprint/74/7/1481.pdf

Marais I F M, Ayyat M S, Gabr H A and Abdel-Monem U M 1996. Effects of heat stress and its amelioritation on reproductive performance of New Zealand White adult female and male rabbits, under Egyptian conditions. Proceedings of 6th World rabbit Congress, Toulouse, France 2: 197-202

Masoero G, Napolitano F, Bergoglio G, Riccioni L and Zoccarato I 1992 Crossbreeding experiment of New Zealand White females with White Giant, Pure and synthetic and stabilized strains in conventional or fasted preslaughter condition. Journal of Applied Rabbit Research 15:166-173

Masoero G, Ubertalle A, Mazzocco P and Battaglini L M 1985 Terminal crossing of New Zealand White and Californian Rabbits. (2) Characteristics on the live animal. Annalidell Istituto Sperimentale per la Zootecnia 18(2): 93-109. (Animal Breeding Abstract 55, No. 1264)

Metzger Sz, Odermatt M, Szendro Zs, Mohaupt M, Romvari R, Makai A, Biro-Nemeth E, Radnai I and Sipos L 2004a. Comparison of carcass traits and meat quality of Hyplus hybrid, purebred Pannon White rabbits and their crossbreds. 8th World Rabbit Congress, 7-10 September 2004, Puebla, Mexico, pp 1422-1428

Metzger Sz, Odermatt M, Szendro Zs, Mohaupt M, Romvari R, Makai A, Biro-Nemeth E, Radnai I and Sipos L 2004b Examination on the carcass traits of different rabbit genotypes. 8th World Rabbit Congress, 7-10 September 2004, Puebla, Mexico, pp 1429-1434

Ozimba C F and Lukefahr S D 1991 Evaluation of purebred and crossbred rabbits for carcass merit. Journal of Animal Science 69: 2371-2378 http://jas.fass.org/cgi/reprint/69/6/2371.pdf

Parigi Bini, R, Xiccato G, Cinetto M and Dalle Zotte A 1992 Effetto dell´età e peso di macellazione e del sesso sulla qualità della carcassa e della carne cunicola.2. Composizione chimica e qualità della carne. Zootecnia e Nutrizione Animale 18: 173-190

Piles M, Blasco A and Pla M 2000 The effect of selection for growth rate on carcass composition and meat characteristics of rabbits. Meat Science 54: 347-355

Pla M, Guerrero L, Guardia D, Oliver M.A and Blasco A 1998. Carcass characteristics and meat quality of rabbit lines selected for different objectives: I. Between lines comparison. Livestock Production Science 54: 115-123.

Pla M, Hernández, P and Blasco, A 1996 Carcass composition and meat characteristics of two rabbits breeds of different degrees of maturity. Meat Science 44(1-2): 75-83

Sánchez J P, Baselga M, Silvestre MA and Sahuquillo J 2004 Direct and correlated responses to selection for daily gain in rabbits. Proceedings of 8th World Rabbit Congress, Puebla, México, pp. 169-174

Szendrö Z S, Radnai I, Biró-Németh E, Romvári R and Milisits G 1996 The effect of live weight on the carcass traits of rabbits between 2.2 and 3.5 kg. In: Proceedings of 6th World Rabbit Congress, Toulouse, France 3: 263-267

Received 22 October 2007; Accepted 27 November 2007; Published 1 May 2008

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