

**DIALLEL CROSSBREEDING EXPERIMENT
IN DANISH AND HUNGARIAN MEAT RABBITS**

2. QUALITY EVALUATION, DISSECTION, AND CHEMICAL ANALYSIS OF CARCASSES

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ABSTRACT : The two rabbit meat breeds, Danish White (D), represented by a 3-way cross of 3 lines from the Danish Institute of Animal Science (DIAS), and Pannon White (H), represented by a synthetic breed from the Pannon Agricultural University (PAU) were used in a diallel crossing experiment carried out simultaneously at the two locations. In the four combinations: DD, DH, HD, and HH the male breed is mentioned first.

Carcass weight averaged 1,650 g for all carcasses. Body length was longest in (HD) carcasses. The dressing percentage was biggest in group (DH).

For fleshiness and conformation of carcasses, group (HD) got the highest score - 7.50 points. Group (DD) got 7.46 points and the two groups (DH) and (HH) got 7.36 and 7.34 points, respectively. Group (DD) and (HD) got the highest score for leg.

At the cutting-up programme, no significant differences in the percentage for forepart were recorded between the four groups. The male carcasses had a significantly higher percentage forepart, 21.5 versus 20.9 for female carcasses. For loin the opposite was found, 35.8% for male and 36.8% for female carcasses, while no significant difference between the sexes was seen for hind part. So, the anatomy

of the sexes seems to be different. M.long.dorsi as a percentage of the carcass weight was significantly higher in group (HD) than in the other groups. It was smallest in group (DD), 10.1%. The groups (HH) and (DH) showed 11.0 and 10.6%.

The percentage of fat free meat was significantly larger in the groups (HD) and (DD) than in the groups (DH) and (HH).

The content of fat was significantly higher ($P < 0.001$) in female than in male carcasses, 10.10% and 8.89%, respectively.

In the female carcass, there was a highly significant correlation between the judged amount of fat and percentage fat in the analysis, $r = 0.54$. In male carcasses the correlation was smaller and not significant, $r = 0.12$. Between carcass weight and points for fleshiness, the correlation was highly significant, $r = 0.64$ and 0.63 for males and females, respectively, but between carcass weight and percentage of protein in the carcasses the correlation was negative and non-significant. The visual judgement of fleshiness/conformation was, in this investigation, much influenced by the weight of the carcass, and only for female carcasses it was related to the fat content of the car-case. Significant differences between groups were found for M.long.dorsi (length as well as relative weight) and for fat free meat, too.

RESUME : Essai de croisement diallele entre lapins de chair Danois et Hongrois. 2/ Evaluation qualitative, dissection et composition chimique des carcasses.

L'essai a porté sur le croisement diallele de deux lapins de races à viande : le Danois Blanc (D) issu d'un croisement à trois voies entre trois lignées provenant du Danish Institute of Animal Science et le lapin Pannon White (H) issu d'une race synthétique provenant de la Pannon Agricultural University (Hongrie), essai qui fut mené simultanément dans les deux lieux d'origine. Dans les quatre combinaisons : DD, DH, HD et HH le mâle est nommé en premier. De 176 à 285 lapins ont été sacrifiés par génotype. Le poids moyen toutes carcasses confondues est de 1 650g. La plus grande longueur de carcasse (35,7 cm vs 35,0 à 35,2 cm) a été enregistrée dans le lot HD. Le plus fort rendement à l'abattage appartient au lot DH, mais les écarts ne sont pas significatifs. Pour le rendement en viande et la conformation des carcasses le lot HD obtient la meilleure note avec 7,5 points/10. Le lot DD obtient 7,46 points et les deux lots DH et HH obtiennent 7,36 et 7,34 points respectivement. La meilleure note sur 5 concernant la cuisse appartient aux lots DD et HD (3,77 et 3,76 vs 3,68 et 3,63 ; $P < 0,01$).

Concernant la découpe, le pourcentage de la partie avant n'est pas significativement différent entre les quatre lots. Les carcasses mâles ont un pourcentage de la partie avant significativement supérieur à celui des carcasses femelles : 21,45 vs 20,9 %. Pour le râble on obtient le

contraire (35,8% pour les mâles et 36,8 % pour les femelles) tandis qu'il n'y a pas de différence significative entre les sexes pour la partie arrière de la carcasse. Donc l'anatomie semble différente selon le sexe.

Le pourcentage du poids de la carcasse représentée par le muscle Longissimus dorsi est significativement plus élevé dans le lot HD que dans les autres lots. Il est le plus faible dans le lot DD : 10,1 %, et de 11,0 et 10,6 % pour les lots HH et DH respectivement.

Le pourcentage de viande dégraissée est significativement plus élevé dans les lots HD et DD que dans les lots DH et HH. Les carcasses femelles sont significativement plus grasses que les carcasses mâles : 10,10 et 8,89 % respectivement.

Pour les carcasses femelles il y a une corrélation hautement significative entre la quantité de graisse évaluée et le % de gras réellement analysé ($r = 0,54^{***}$). Pour les carcasses mâles la corrélation est plus faible et non significative, $r = 0,12$. La corrélation entre le poids de la carcasse et les scores de rendement en viande est hautement significative, $r = 0,64^{***}$ et $0,63^{***}$ entre mâles et femelles, mais entre le % de protéines et le poids de la carcasse la corrélation est négative et non significative. L'appréciation visuelle du rendement en viande/conformation a été, dans cette étude, très influencé par le poids de la carcasse, et lié au contenu en graisse seulement pour les carcasses femelles. Des différences significatives entre lots ont été trouvées concernant Longissimus dorsi (longueur et poids relatif) ainsi que pour la viande dégraissée.

INTRODUCTION

At the Pannon Agricultural University, Faculty of Animal Science, Kaposvár, Hungary, and the Danish Institute of Animal Science, Foulum, Denmark, a diallel crossbreeding experiment has been carried out. From each of the two institutes 25 meat rabbits were transferred to the opposite Institute to illustrate the influence of environment on reproduction, liveability, growth rate, and carcass traits.

In connection with the results from the growing period of the rabbits in the diallel crossbreeding experiment (JENSEN *et al.*, 1996) the rabbits from the four groups were investigated during and after slaughter. The report covers the results

collected at the Danish Institute of Animal Science (DIAS) and, as for the growing period, the results of the parallel investigation in Hungary will be published in a separate paper.

It was the purpose of the experiment to produce a description of the carcasses from the two lines and their reciprocal crosses, and to test the standard procedure for cut-up of rabbits (BLASCO, 1993).

MATERIAL AND METHODS

The origin of the two lines and the breeding plan as well as feeding and methods were described in the first report (JENSEN *et al.*, 1996). Male x female is used in the breeding plan (D for

Table 1 : Carcass conformation and fatness.

Line	DD	HD	DH	HH	P**
Rabbits slaughtered, number	201	176	285	215	
Weight before slaughter, kg	2.84	2.90	2.79	2.82	
Cold carcass weight, kg	1.65	1.68	1.62	1.65	
Dressing per cent*	57.9	57.8	60.1	58.3	ns
Body length, cm	35.0 ^a	35.7 ^b	35.3 ^a	35.2 ^a	0.004
Fleshiness for leg (1 to 5 points)	3.77 ^a	3.76 ^a	3.68 ^b	3.63 ^b	0.007
Fleshiness for loin (1 to 5 points)	3.69	3.74	3.68	3.71	ns
Total (1 to 10 points)	7.46	7.50	7.36	7.34	ns
<u>Abdominal fat:</u>					
Too much, %	35	33	35	43	
Suitable, %	58	62	61	53	ns
Lack of fat, %	7	5	4	4	

* Including head ** Probability of test for line effect

Danish and H for Hungarian rabbits). Prior to slaughter the rabbits were fasted for 12 hours with access to water only and before being transported to the abattoir at DIAS they were weighed. After slaughter the carcass was chilled in water for one hour and the body length from *atlas vertebra* to the 7th *lumbar vertebra* was measured. The cold carcass weight - including head, abdominal fat and kidney fat, but not the kidneys - was recorded. In a subjective classification system, points from 0 to 10 were given for carcass conformation, divided in 0 to 5 points for fleshiness and conformation of the legs, and 0 to 5 for fleshiness of the back. The degree of the fatness was evaluated by grading the carcass in one of the following groups: If = too much fat, I = suitable amount of fat, and II = too little fat. Dressing percentage was calculated from the live weight after 12 hours' fast - just before delivery to the abattoir - and the weight of the chilled carcass.

Cut-up and dissection procedure for carcasses

From each of the four groups carcasses of 12 males and 12 females were selected for cut-up and dissection.

The cutting-up programme followed the standard procedure (BLASCO *et al.*, 1993). The head was cut off in the occipital articulation (*atlas vertebra*). The front part was cut off between 3rd and 4th ribs, and the back part was cut off through the 7th vertebra.

The back was separated by dissection into loin, lean meat, fat, and bone. The fillet (*M. long.dorsi*) was trimmed so only the muscle remained.

The remaining muscle tissues, breast meat, tenderloin and scraps from the fillet were fat-trimmed and the weight was registered as lean meat.

Chemical analysis of carcasses

10 male and 10 female carcasses were selected for chemical analysis. The first criterion was to have a male and a female from the same litter to be able to compare the two sexes and the second criterion was to get the same average carcass weight in the four groups. The carcasses were deep-frozen at -30°C and stored at -21°C until the analyses were to be carried out. For comparison the results of the subjective evaluation of the selected carcasses are presented together with the chemical analyses. The methods followed the standard procedure.

The frozen carcasses were divided into small pieces on a chopping block and minced in a food mixer in 3 to 4 mm pieces, which were again mixed in a large blender.

An average sample of approximately 300 g was freeze-dried until dryness and air equilibrated for 48 hours at room temperature. Premilling was undertaken under liquid nitrogen in a food processor with knives in horizontal position. A dry matter factor was carried out for correction of the amount of water contained in the samples when testing the analysis for water, ash, nitrogen, and fat after HCl-hydrolysis and extracted by petroleum ether.

Statistical methods

The statistical tests of data regarding anatomical measurements and chemical analyses as well as subjective scores were performed on individual data according to the following model:

$$Y_{ijkl} = \mu + \alpha_i + \beta_j + \gamma_k + b \text{ weight}_{ijkl} + \epsilon_{ijkl}$$

where

- Y_{ijkl} = observed individual value
- μ = overall means
- α_i = effect of the i^{th} line or line cross $i = 1$ to 4
- β_j = effect of being born in the j^{th} litter of a doe $j = 1$ to 6
- γ_k = effect of the k^{th} sex $k = 1, 2$
- b = regression of weight at slaughter
- ϵ_{ijkl} = non-explained random effect $N(0, \sigma^2)$

An analysis of variance was carried out using the GLM procedure of SAS (1989) taking into account that the data of the model were unbalanced as to some of the effects. Therefore, means of the effects are estimated as Least Square Means (LSM).

As a first approach an analysis based on the full model including interaction effects between line and sex was performed. In the next step, analyses were performed in which non-significant effects had been removed from the model.

Statistical significance was detected by the F-test and for the line/line cross individual differences were detected by the t-test.

Tests for heterosis were performed as a linear contrast of the pure lines versus their reciprocal crosses and tested against the error variances of the model.

Table 2 : Anatomic and tissue composition of carcasses

Group	No.	Fore-part	Loin	Hind part	<i>M. longissimus dorsi.</i>		Fat free meat
		%	%	%	Length cm	% of carcass	%
DD	26	21.3	36.3	34.5	20.9 ^a	10.1 ^d	13.4 ^b
DH	26	21.1	35.9	35.0	21.4 ^{ab}	10.6 ^c	12.3 ^a
HD	24	21.4	36.3	34.5	21.5 ^{ab}	11.7 ^a	13.5 ^{bc}
HH	24	21.1	36.6	34.4	21.9 ^b	11.0 ^b	12.7 ^{ac}
Males	51	21.5	35.8	34.5	-	10.5	13.3
Females	49	20.9	36.8	34.6	-	11.2	12.6
Level of significance	Lines	ns	ns	ns	0.025	0.001	0.008
	Sex	0.001	0.001	ns	ns	0.020	0.001

A test of different score of abdominal fat in the four lines/line crosses was performed by the χ^2 -test.

Correlations between traits were carried out based on the uncorrected data using the methods of product-moment correlation to continuous variables and the Spearman rank correlation to categorical data.

RESULTS

Carcass length, conformation, and fatness

For practical reasons there was a period of up to a fortnight between the end of test and the processing of rabbits, so the average weight before slaughter was about 150 g higher than the weight at the end of the test period. The average weight before slaughter was 2.83 kg, and the weight of the cold, washed carcass was 1.65 kg, which resulted in an average dressing percentage of 58.3. The Danish (DD) and the Hungarian (HH) groups averaged 57.9% and 58.3%, respectively. (HD) was 57.8% and similar to (DD) while (DH) had the highest dressing percentage, 60.1, but no statistical significance was found. By including the number of the litter in the statistical analyses it was found that it has a significant influence on the traits, except for the dressing percentage.

The body length was not statistically different between (HH), (DD), and (DH), 35.2 cm, 35.0 cm, and 35.3 cm, respectively, while (HD) was significantly longer, 35.7 cm.

Carcasses of the Danish does got the highest score for carcass conformation and fleshiness. The line cross (HD) got 7.50 points in total for back and leg. Group (DD) got 7.46, while the two groups of Hungarian born does (DH) and (HH) got 7.35 and 7.34 points of 10 possible. Group (DD) got a higher score for leg than for back as opposed to what was seen in group (HH).

Of the two crossbred groups (HD) and (DH) 62% of the carcasses had a suitable amount of abdominal and kidney fat, as scored by the visual judgement of the amount of fat. In lines (DD) and (HH) 58% and 53% were in this class. In the groups (DD), (HD), and (DH) about one third had too much fat, but in group (HH) the percentage was 43. At the total judgement only a few carcasses had a lack of fat. Highest result was in group (DD) with 7%, while the other three groups showed 4% to 5%.

A statistical test of numbers in the three categories using χ^2 did not demonstrate that the differences were significant.

Carcass cut-up and dissection

No significant differences were obtained between the forepart percentages in the four groups as seen in table 2. Therefore, it could be concluded that no effect of crossing was observed. A similar result was seen in the loin part, but the *M. long.dorsi* part was significantly largest in group (HD) with 11.7% of the carcass weight, and smallest in group (DD) with 10.1% against 11.0% in group (HH).

No sex times line interaction was detected in any of the traits whereas a considerable sex effect was seen for several traits. The effect of the number of the litter was considerable and was increasing with regard to forepart and loin percentage and the inverse for hind part. In particular the fat free meat percentage increased, from 10% in the first litter to more than 14% in the fifth litter.

The average length of *M. long.dorsi* was 21.9 cm in group (HH) and 20.9 cm in group (DD), and the line crosses were in between. The same pattern was seen for the relative weight of *M. long.dorsi* except for a significant heterosis effect for line cross (HD).

The hind part of the carcass averaged 35% of the carcass and it was greater in the two groups (DD) and (DH) than in the other groups (HD) and (HH), which is in accordance with the opposite tendency found for loin and the *M. long.dorsi*.

Chemical composition of carcasses

At slaughter (table 3) the average age was almost the same in the four groups.

For males the carcass weight averaged 1,589 g and for females 1,570 g, showing a sex difference on weight of 1.2%. The average weight in each of the four groups was for (DD) 1,619 g, 1,589 g for (HD), 1,589 g for (HH), and 1,523 g for (DH). These results show that the second selection criterion was reached as no significant difference was found between the four groups.

In the chemical analysis only a small and non-significant difference was obtained in the content of protein between the four groups as well as between sexes. As seen in table 3, the

Table 3 : Chemical analysis and subjective judgement of cold carcasses

Group	Age	Chemical Analysis				Weight of carcass (g)	Score for fleshiness		
		d	Water %	Ash %	Protein %		Fat %	Leg	Loin
DD	81.3	68.1	4.22	18.7	9.74	1,169	3.55	3.60	7.15
HD	79.7	68.1	4.14	18.8	9.72	1,589	3.53	3.65	7.18
DH	80.4	68.4	4.18	18.6	9.41	1,523	3.35	3.47	6.82
HH	80.7	68.8	4.29	18.6	9.11	1,589	3.48	3.65	7.13
Males		68.9	4.19	18.7	8.89	1,589	3.50	3.64	7.14
Females		67.8	4.23	18.7	10.10	1,570	3.45	3.55	7.00
Level of significance	Line	ns	ns	ns	ns	ns	ns	ns	ns
	Sex	0.015	ns	ns	0.019	ns	ns	ns	ns

highest content was found in carcasses from group (HD), which contained 18.8% protein.

As the correlation between points for carcass conformation and fleshiness, and protein content in carcass were small, $r = -0.07$ for males, and $r = -0.13$ for female carcasses, the visual judgement of carcass may give a picture of carcass conformation and carcass fleshiness, but it seems not to be correlated to protein in the carcass.

The fat content varied only a little and in the chemical analysis no significant difference between the four groups was observed. Totally for all four groups, a significant sex difference was observed. Carcasses from males contained 8.89% fat and females 10.10%, ($P < 0.019$).

The carcass content of ash was at 4.12%, totally. Between the four groups and also between sexes, only small and non-significant differences were obtained. Carcasses from males and females contained 4.19% and 4.23% ash, respectively.

In the Danish experiment water content averaged for all carcasses 68.4%, showing 68.9% in male carcasses and 67.8% in those from female rabbits. In the two groups bred by Danish

does ((DD) and (HD)) the content was a little smaller (68.1%) than in those bred by Hungarian does ((DH) and (HH)) showing 68.4% and 68.8%, respectively.

At the visual judgement of carcasses for conformation and fleshiness, the carcasses from (DH) received a lower score for loin as well as for leg than did the other groups. Totally, carcasses from male rabbits received a higher score than female carcasses.

The visual evaluation of the fat deposition in the carcasses selected for chemical analyses is similar to the evaluation of all carcasses (table 1) except for group (HH). It seems that the difference is related to the higher percentage of carcasses in the group "lack of fat".

Correlations between chemical analysis and visual judgement

Table 4 shows the coefficients of correlation between the visual judgement and results from chemical analyses. For female carcasses there was a highly significant correlation between judged abdominal fat and per cent fat measured by

Table 4 : Coefficients of correlation between visual judgement and chemical analyses

Chemical analysis	Visual judgement					
	Males			Females		
	Carcass weight	Fleshiness	Abdominal fat	Carcass weight	Fleshiness	Abdominal fat
Fleshiness	0.64***	-	-	0.63***	-	-
Abdominal fat	0.04	-0.04	-	0.15	0.32**	-
Dry matter, %	+0.06	0.04	0.24	0.24	0.26	0.57***
Protein, %	-0.03	-0.07	-0.13	-0.05	-0.13	-0.27
Fat, %	0.10	0.15	0.12	0.19	0.23	0.54***
Ash, %	0.05	0.02	-0.17	-0.25	-0.27	-0.17

chemical analyses, $r = 0.54^{***}$, whereas in male carcasses it was lower and non-significant, $r = 0.12$.

For all carcasses, the correlation between carcass weight and points for fleshiness was highly significant, $r = 0.64^{***}$, and no sex difference was observed. Between fleshiness and per cent protein the correlation was small, $r = 0.07$ for male and a little higher, 0.13, for female carcasses. Between weight of carcass and per cent protein, the correlation was small and negative for all the carcasses, -0.04, while it was positive between weight of carcass and judged abdominal fat, $r = 0.04$ for male, and $r = 0.15$ for female carcasses.

DISCUSSION

No significant difference of dressing percentage between the four groups was observed. The same average was calculated in the two parent groups, which was a little higher than in both of the diallel crosses. This is in harmony with KROGMEIER and DZAPO (1991), who found a lower dressing percentage in crosses than in the parent breeds, Californian and New Zealand White. A similar result is described by ORAVCOVA and BERBER (1991), who noted a higher dressing percentage in a non-inbred line than in crosses between these lines and an inbred line. Analogous results are reported by JENSEN (1992), who - when crossing three inbred lines - found a lower dressing percentage in line crossings than in each of the three lines. Contrary to this, BRUN *et al.* (1992) noted a low, but significant heterosis effect in dressing percentage.

The visual judgement of carcass fleshiness in the four groups showed a significant line effect for fleshiness of leg, which seems to be connected to an influence of the two lines. For fleshiness of the loin no significant line effect was detected. But no crossing effect was found, while KROGMEIER and DZAPO (1991) noted a lower score to crosses than to the parent breeds, when crossing New Zealand White and Helle Großsilber.

The two diallel crosses had less abdominal and kidney fat than the average of the two parent groups. The largest amount of fat was seen in group (HH) and the smallest in the (HD) group. The fact that the crosses have less abdominal fat than the parent breed was also observed by OZIMBA and LUKEFAHR (1991) who - by crossing New Zealand White and Californian, which are also breeds for meat production - found a lower amount of abdominal fat in the crosses than in the two breeds. On the other hand, KROGMEIER and DZAPO (1991) as well as BRUN *et al.* (1992) noted a larger amount of fat in carcasses from crosses than in carcasses from the parent breeds. DELTORO and LOPEZ (1986) found significant influence of line on abdominal fat, and JENSEN (1992) observed in a three-line crossing programme with the breed Danish White that the fatness was at the same level in the crosses as in the lines.

DELTORO and LOPEZ (1986) reported a larger *M. long.dorsi* weight in carcasses from male than in those from female rabbits. In this experiment the opposite was seen, when the weight of the muscle was related to the weight of the carcass, whereas for length no effect of the sex was found. But for lines a significant effect was seen for both measurements.

As to the amount of fat free meat, the two sexes also showed significantly different quantities.

The division in forepart, loin and hind part showed significant influence of sex for the two first parts only.

All material together, the weight of the hind part was about 10% higher than the weight of the forepart. This is not in agreement with reports from neither OSMAN (1991) nor

OZIMBA and LUKEFAHR (1991), indicating that the forepart cut was not placed between the 3rd and 4th ribs as in the Danish-Hungarian project.

Regarding 'fat free meat' both the sex and the line effect was significant, indicating the lowest percentage of 'fat free meat' in females and in the groups (HH) and (DH). This result is interesting in relation to the values obtained for *M. long.dorsi* and the observations reported by DELTURO and LOPEZ (1986).

The investigation of a visual judgement of the carcass quality in the rabbits selected for chemical composition and the chemical composition in Danish and Hungarian meat rabbits and their crosses only showed small differences as to points for fleshiness. Generally, the female carcasses got a little lower scores than the male carcasses.

EL-GAMMAL *et al.* (1984) found from chemical analyses of meat from 9 months old meat rabbits, that meat from females had a higher content of protein than had male rabbits, 21.8% and 21.2%, respectively, but the difference was not significant. This result was not confirmed in this experiment where the protein content was the same for the two sexes. In meat from 9 months old Angora rabbits at a weight of 2,000 g for females and 1,900 g for males, WILSON and MORRIS (1932) found 20.2% protein in meat from females and 21.1% in meat from males. Also in this analysis meat from male rabbits had a higher content of protein than meat from females. When these 9 months old rabbits had a higher content of protein than 3 months old Danish rabbits, it may be due to the fact that the Danish project included whole carcasses, while the reported trials included meat only, but also the age seems to be an important factor. THOMSEN (1987) found rising protein levels in chickens from age 0 to 42 days, varying from 16.5% to 19.4%. This experiment was like the one with rabbits based on whole carcasses.

A clearly higher fat content in female than in male carcasses was observed by EL-GAMMAL *et al.* (1984), who found a sex difference of 1.3% which is at the same level as seen in the Danish project.

The ash content of 4.21% is more than was found in chickens by THOMSEN (1987) who in 42 days old chickens found an ash content of 2.9% in the whole carcass. The difference may be due to a stronger skeleton in meat rabbits than in chickens. EL-GAMMAL *et al.* (1984) as well as WILSON and MORRIS (1932) found in dry matter from rabbit meat an ash content of 1.4% and 5-6% in the whole carcass.

Water content in the carcasses was a little smaller in this experiment than found by EL-GAMMAL *et al.* (1987), who in male carcasses found 71.1% against the Danish male carcasses 68.9%. The same difference is seen in the female carcasses, 68.9% and 67.8%, respectively. The difference in water content between the sexes was significant in the present experiment. The difference was 1% higher in the referred 9 months old rabbit carcasses than in the Danish 3 months old carcasses.

CONCLUSION

The dressing percentage was not influenced and the suitable amount of fat positively affected by crossing. A significant difference in length of *M. long.dorsi* between the rabbits of Danish and Hungarian origin was found.

A visual judgement may provide valuable information about the carcass content of abdominal fat, while providing less information about protein in the carcass.

The recommendations given in "Harmonization of criteria and terminology in rabbit meat research" by BLASCO *et al.*

(1993) was essential for the project and make a comparison to results produced by the same procedure meaningful.

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