



Hungarian University of Agriculture and Life Sciences

**Examination of production and
reproduction parameters of cross-bred
varieties in hens for
alternative husbandry**

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1 Background of research, objectives

The market for poultry products is continually increasing nowadays, which can be met to a large extent by industrial, closed production systems (Horn, 2014). However, quality, environmental and animal welfare issues have led to significant consumer demand for products of higher quality, non-intensive production on the market (Szabó, 2017).

Each of Europe's main domesticated animal species has at least one native Hungarian breed. The chicken breeds stand out among them (Parliamentary Resolution 32/2004 (19 April), Decree 4/2007 (18 January, FVM-KvVM joint decree), 93/2008 (24 July) FVM (Ministry of Agriculture and Rural Development) decree, 38/2010 (15 April) FVM Decree). However, these native Hungarian breeds have declined. The National Centre for Biodiversity and Gene Conservation, Institute of Farm Animal Gene Protection (NBGK-HGI) and its legal predecessors have played a key role in the gene conservation of these native Hungarian breeds.

In modern, closed-system technologies, corresponding genotypes have been produced in order to achieve ever-increasing and more efficient production, during which the varieties have experienced a greater transformation than in previous years. A number of beneficial features have been phased out as a result of these improvements (Besbes et al., 2008, Bianchi et al., 2013, Bobbo et al., 2013, Szalay, 2015). While genotypes produced in the Carpathian Basin have maintained these characteristics, they are excellent for production in alternative husbandry technologies, even though they can produce a commodity for a longer period of time under different environmental conditions over a long period of time, even with less effort (Szalay, 2015).

The most important objective of my research was to develop genotypes using crossbreeding methods so that native Hungarian chicken breeds could be used in public breeding.

Based on preliminary performance testing, I selected the Yellow Hungarian (YH) and Speckled Hungarian (SH) species as the base for the crosses and paired them with the intense genotypes bred in Hungary, the paternal lines of TETRA H (T) and TETRA HARCO (TH). In the first generation, I used these genotypes to establish two-line crosses from which we can pick those appropriate for meat and egg production. In the second generation, my intention was to create three-line genotypes that could be used in alternative husbandry for meat production. In addition, other production and quality characteristics of the Yellow Hungarian chicken and the Speckled one were investigated to complement the performance tests.

My further aim was to see whether there was a difference in reproductive biology between first-generation crossed genotypes since meat production and reproductive biology traits are negatively correlated.

2 Material and method

Research has been ongoing for many years, and two generations have been developed during that period.

The genotypes of Bábolna were selected for their suitability for alternative husbandry techniques. I selected genotypes that can positively affect the meat production of roosters (TETRA H) and the egg production of hens (TETRA HARCO) for developing the first generation. However, while designing the second generation, I was already searching for a paternal partner (TETRA HB COLOR) which could help improve meat production.

The Yellow Hungarian and Speckled Hungarian chickens, as well as the TETRA H and TETRA HARCO genotypes were used to create the first generation. To produce reciprocal crosses, the paternal and maternal lines of the hybrids were used. As a result, in the first generation, eight crosses were added, plus four additional control classes (Yellow Hungarian, Speckled Hungarian chicken, TETRA H, TETRA HARCO).

At 12 weeks of age, the meat production of the first-generation roosters and meat quality parameters (live weight, carcass weight, carcass percentage, proportion of valuable meat parts, pH, color, tenderness) were studied. Data on chickens from the first egg production period were gathered (egg production, weight, index, shell strength, shell thickness).

The reproductive biological properties of the first-generation hens were examined after mating them with TETRA HB COLOR (THB) roosters (hydrolysed points produced by spermatozoa in the inner perivitelline layer over the germinal disc (IPVL holes), embryonic mortality).

Four crossbred hens were selected for raising based on the outcomes of the studies: TxYH, YHxTH, TxSH, and SHxTH, as well as purebred YH and SH chickens as control

groups. After the molting period, young (28-week-old) THB roosters were mated to hens.

The egg production, weight, index, shell strength, shell thickness, number of penetration openings, and early embryo mortality of TxYH, YHxTH, TxSH, SHxTH, YH and SH genotype hens of the same age were examined during the second egg production period.

I hatched some of the eggs from the second egg production cycle, which resulted in creating the second generation. While examining the second generation, I produced 6 crosses (THBxTxYH, THBxYHxTH, THBxTxSH, THBxSHxTH, THBxYHxYH, THBxSHxSH), purebred YH and SH, as well as ROSS 308 and COBB 500 hybrids. We used two types of husbandry technologies, one free range and one closed. During slaughter, I examined live weight, carcass weight, carcass percentage, proportion of valuable meat parts, pH, color, and tenderness.

3 Results

3.1 The meat production and meat quality characteristics of the first generation

In terms of live and slaughter weight, the genotypes in which TETRA H was active during the production of the first generation were typically greater than both the Yellow Hungarian and the speckled Hungarian chickens. The beneficial impact of TETRA H can be seen from the fact that its cross-linked genotypes are slightly heavier than TETRA HARCO's genotypes.

In contrast to live and slaughter weight, fewer significant results were detected when examining the slaughter percentage. With the exception of THxSH, none of the crosses varied from the Yellow Hungarian chicken, and all crosses were superior for the Speckled Hungarian chicken with the exception of THxSH. The proportion of valuable meat parts in the crossed genotypes was close to that of the original genotypes. Furthermore, when I measured the pH and color of the breast meat 24 hours after slaughter, I observed no statistically significant variations. The Yellow Hungarian chicken and the TxSH crossbreed had the lowest tenderness scores, i.e., just 2 kg, during the experiments. The shear force value of the Yellow Hungarian chicken was significantly smaller than the YHxT and YHxTH crosses. Furthermore, the TETRA H and TETRA HARCO classes had higher values than the Yellow Hungarian and Speckled Hungarian chickens.

3.2 The meat production and meat quality characteristics of the second generation

The hybrid genotypes (ROSS 308 and COBB 500) achieved statistically significantly higher body weights than the other genotypes, independent of husbandry technology, and the crosses were heavier in all cases (live and slaughter weight)

than purebred Yellow and Speckled Hungarian chickens, as anticipated. In the free-range type, only the Yellow Hungarian chicken had a slightly lower slaughter percentage than the COBB 500 hybrid. The hybrids had a considerably higher percentage of proportion of valuable meat parts than the crossed genotypes and the Yellow and speckled Hungarian chickens. Their hybrids were similar to the native varieties. As for the second-generation crosses, no significant differences in pH were found. When measuring the color of the breast samples, there were no differences between the L * and * parameters of the examined genotypes, which gave the lightness and redness of the meat. However, in the free-range type, the b * values of the YH and (TxSH) xTHB genotypes were higher, so they were yellower than the COBB 500 hybrid.

The COBB 500 hybrid had the highest shear force value in free range, which was significantly higher than all other genotypes. The ROSS 308 hybrid came next, which just differed from (YHxTH)xTHB and (YHxBH)xTHB crosses. The other YH-based genotypes had a lower shear force value than the (YHxTH)xTHB community. The COBB 500 hybrid shear force value in the closed type was only statistically higher in the (SHxSH)xTHB and YH classes. ROSS 308 varied from the same genotypes as in free range. Purebred YH had a lower mean value than all crosses, and the genotypes (TxSH) THB and (SHxTH)xTHB also varied in this technology.

3.3 Comparison of meat production and meat quality of identical genotypes in free range and caged types

When comparing live and slaughter weight, I only found a substantial difference between free range and caged modes in two cases. In caged conditions, the ROSS 308 gained more body weight, as predicted. The (TxYH) xTHB cross, on the other hand, performed better in the free-range mode. When examining the slaughter percentage, I only found one case

where there was a noticeable difference: the yield of the (SHxSH) xTHB genotype was lower in the caged type than in free range. In cages, the Speckled Hungarian chicken had a higher proportion of valuable meat than in free range although this is in contrast to the ROSS 308 genotype, which had a higher proportion of valuable meat parts in free range. The pH of the breast samples differed only for two genotypes. The pH in free range was smaller than that of the caged circumstances of both the Yellow Hungarian chicken and the COBB 500. Between the genotypes studied, there was no statistically meaningful variation of color between the L * and a * results.

However, examination of the yellowness (b *) of the samples showed that the Yellow Hungarian chicken and the Speckled Hungarian chicken were yellower in free range, while those of the (TxYH)xTHB and (TxSH)xTHB genotypes were yellower in the cages. A total of 4 genotypes ((YHxTH)xTHB, (SHxSH)xTHB, ROSS 308, COBB 500) had significantly higher shear force values in free range. In contrast, this property of the (SHxTH)xTHB genotype was higher under caged circumstances.

3.4 Results of first-generation egg production and egg quality

I did not find any permanent differences in terms of egg production when comparing the Yellow Hungarian chicken and its crossbreeds. However, the egg production of speckled Hungarian chickens was significantly worse than that of the TxSH and SHxTH genotypes. In a statistically verifiable way, the weight of the eggs from the YHxTH cross was greater than that of the purebred Yellow Hungarian chicken and the TxYH genotype. The latter two, on the other hand, did not differ in a statistically significant way. Individuals with the SHxTH

genotype reliably laid considerably larger eggs than speckled Hungarian chickens during the period of study. There were no consistently statistically important differences between the genotypes analyzed regarding egg index, shell thickness, or strength.

3.5 Reproductive biological results

In the case of Yellow Hungarian chickens, the proportion of embryos that died during incubation increased in the second production period, while the proportion of infertile eggs decreased. Fertility improved by a statistically significant amount. The same does not hold true for the YHxTH crossing. The proportion of infertile and dead embryos in incubation was similar to the previous ones, and the proportion of normal embryos did not differ, either. The number of IPVL holes differed statistically for only two genotypes between the first and second egg production cycles. It increased in Speckled Hungarian chickens and decreased in SHxTH crosses. In the case of the latter cross, fertility declined due to the lower number of openings. The proportion of embryos that died during incubation also increased, but the number of embryos that developed normally did not change. In Speckled Hungarian chickens the number of IPVL holes increased, while the proportion of infertile eggs decreased. Nonetheless, during the second production period the percentage of naturally developing embryos remained unchanged. The TxSM genotype stands out among the Yellow Hungarian chicken crosses. In contrast to the YH and YHxTH genotypes, this cross had statistically verifiable more penetration openings. As a result, the percentage of infertile eggs was significantly lower, whereas the proportion of normally developing embryos was higher despite the fact that this genotype created the most embryos that died during incubation. The SHxTH genotype

stood out among the Speckled Hungarian chicken crosses; this cross had the most IPVL holes, the fewest infertile eggs, and the largest proportion of normal embryos.

SHxTH had slightly more penetration openings than the Yellow Hungarian chicken during the second egg development period in comparison to the TxYH cross. Furthermore, as compared to the Yellow Hungarian chicken, the percentage of infertile eggs at these crosses was statistically smaller. In contrast, the proportion of embryos with normal development did not differ.

There was a significant difference in the number of penetration openings between SHxSH and SHxTH genotypes, but this difference was no longer reflected in the number of normal embryos.

3.6 New scientific results

1. I developed two- and three-line crosses with Yellow and Speckled Hungarian chickens, which have not been found in the literature yet with the inclusion of the TETRA H, TETRA HARCO, and TETRA HB COLOR genotypes on a fully Hungarian genetic basis.
2. I pointed out that the production performance of the Yellow and speckled Hungarian chickens did not change as compared to data found in the 2000-2010 literature. With this, I demonstrated that native chicken breed can be sustained at the same level due to existing gene conservation activities.
3. I defined the genotypes that can be regarded as possible breed candidates for meat production (TETRA H x Yellow Hungarian chicken, (TETRA H x Yellow Hungarian chicken) x TETRA HB COLOR and (TETRA H x speckled Hungarian chicken) x TETRA HB COLOR) and egg production (Yellow Hungarian x TETRA HARCO chicken and speckled Hungarian chicken x TETRA HARCO).
4. I discovered that the same favorable meat quality can be found in crosses as in native breeds, showing that meat quality (pH, color, tenderness) does not shift in a negative direction in generations.
5. I concluded that improving meat quality traits by crosses did not have a negative impact on fertility (hydrolysed points produced by spermatozoa in the inner perivitelline layer over the germinal disc, embryonic mortality).

4. Conclusions and recommendations

When comparing my results to those of other literature sources, there were a few difficulties. The parameters of the experiments in each publication vary, mostly in terms of fattening and egg production times. In addition, there are variations in raising conditions and nutrition, and some of the data in previous scientific publications were incomplete. As a result, it is difficult to tell how much better the native Hungarian varieties or proven crosses are than the genotypes used in other studies. However, paint a picture of their position in the world. On this basis, it can be concluded that native Hungarian breeds produce more meat and eggs than native African and Asian genotypes. This may be because domestic genotypes have already undergone some selection, the keeping and feeding system of better, and they have already been improved by crossing (Márta, 1962). However, it can also be stated that they lag behind hybrids and genotypes used in alternative husbandry.

Due to the features of different genotypes, comparing fattening periods is often difficult. Each variety and genotype mature at a different rate due to its genetic ability. This, of course, is also dependent on local demands and cultural factors. 1.5 kg live weight is expected in some African and Asian countries, while it is 2.5 kg in European and American markets (Yang and Jiang, 2005).

As a consequence, deciding the slaughter age is crucial when comparing various genotypes. When all genotypes are slaughtered at the same time (for example, on a specific day of life), certain genotypes are slaughtered too early or too late, so their data are not always representative of the product being sold. In my research, I fattened the ROSS 308 and COBB 500

hybrids in the second generation for 14 weeks, which does not correspond to the raising time in practice. This may have caused large standard deviations of live weight in these hybrids.

The gene bank storage (*in vivo*) of native Hungarian chicken breeds has been concentrated in Gödöllő since the early 1990s (NBGK-HGI and its predecessors), (Szalay, 2015). In comparison, universities (Szeged, Debrecen) and small breeders also have them in smaller stocks. The varieties in the NBGK-HGI are kept under the same raising and feeding conditions from the start, using the same breeding process. Every two years, the stocks are re-bred, with 300-500 laying hens and their roosters being placed in 8-10 households (NBGK-HGI records, 2020). As a result of my findings, it can be concluded that the production performance of Yellow and Speckled Hungarian chickens was not substantially different from that of previous literature records (Sófalvy and Vidács, 2002, Sófalvy et al., 2006, Konrád et al., 2007, Konrád and Kovácsné Gaál, 2008, Weber et al., 2008, MGE 2009a, MGE 2009b). To sum up, native hen breed production can be sustained at the same level as traditional gene conservation practice.

Crossed genotypes outperformed native genotypes, which is consistent with the findings of other researchers who used crosses based on Asian and African native varieties (Mohammed et al., 2005, Chen et al., 2007, Adeleke et al., 2010, Islam and Nishibori, 2010, Yamak et al., 2014, Padhi, 2016, Promket et al., 2016).

Not excellent results were obtained based on meat quality examinations. There are no genotypes that may have differed from the others for any of the traits tested depending on the criteria I examined, so none can be highlighted. The shear force values of the breast tests, which are related to tenderness, are the most interesting findings. The results of

instrumental and sensory research show a tight correlation ($r=0.7-0.9$) (Owens et al., 2004). In general, 3 kg is the upper limit for meat that can be graded as crisp (Miller et al., 2001). The larger-breasted ROSS 308 and COBB 500 hybrids in the research outperform this. The diameter of muscle fibers varied by genotype, with native breeds having a smaller diameter than fast-growing breeds (Geng et al., 2003, Chen et al., 200, Koomkrong et al., 2015). As a result, one explanation for the higher shear force values of the hybrids may be their greater muscle fiber diameter. Furthermore, variations between native breeds and their crosses can be explained by a strong positive correlation between live weight and muscle fiber diameter ($r = 0.84$) (Koomkrong et al., 2015). This is particularly noticeable in the first and second generations of the Yellow Hungarian chicken.

The quality of muscle connective tissue, mostly collagen, will also influence crispness, although this is only a concern in older animals, not in the fast-rearing time of modern hybrids (35-42 days) (Fletcher, 2002).

The production rates of free-range groups are usually worse in most publications (Castellini et al., 2002; Wang et al., 2009; Li et al., 2016,). In contrast, Fanatico et al. (2005) did not confirm these results, live weight, feed consumption, and carcass percentage were the same for fast- and slow-growing genotypes in both free range and caged conditions.

In most of cases I found similar results except the feed conservation ratio. The pasture (grass), which may have influenced the results.

Just a few studies have looked at the reproductive biological properties of crossbreds produced from various species and hybrids; most studies have looked at the reproductive biological parameters of different breeds and genotypes. Fertility is higher in these situations, probably due to the heterosis effect, than in purebred pairs.

In my own research, I looked into the reproductive biological traits of crossbred chickens. While these genotypes had a higher body weight, their reproductive biological characteristics did not vary from the original varieties in a negative way. As a result, it can be concluded that the increased meat yield brought on by crossbreeding had little negative impact on the reproduction of first-generation hens.

Other research has also been done on crossing native varieties in the hopes of achieving greater performance, and two- and three-line crosses have been established in most cases (Yang and Jiang, 2005). While animal performance has improved, long-term project sustainability has not always been successful due to insufficient feed and medicine supplies and a lack of market access for products (Besbes et al., 2007).

Several of the crosses I have created can be recommended for breeding (meat production: TETRA H x Yellow Hungarian chicken, TETRA H x speckled Hungarian chicken, (TETRA H x Yellow Hungarian chicken) x TETRA HB COLOR, (TETRA H x speckled Hungarian chicken) x TETRA HB COLOR, egg production: Yellow Hungarian x TETRA HARCO chicken and speckled Hungarian chicken x TETRA HARCO) from both two- and three-line crosses. However, in my opinion, the current economic environment is not suitable for maintaining three-line crosses.

The scheme of the pairings and crosses used were ideal for producing genotypes that are superior in production but not worse in quality than native varieties. Since these genotypes are ideal for cost-effective production in alternative technologies, they will become more commonly used. However, this necessitates the maintenance of parental herds in continuous purebreds. Native varieties are therefore maintained in a causal and expedient manner, thus promoting their *in vivo* gene survival.

5 Publications on the topic of the dissertation

Journal articles with an impact factor in a foreign language

1.

Drobnyák, Á.; Phuong, T.N. Lan; Heincinger, M.; Kustos, K.; Almási, A.; Szalay, I.T.; Bódi, L.; Szabó, R.T.; Weber, M. (2019): The Positive Effect of Crossing Speckled Hungarian Breed with Commercial Lines in Term of Meat Production and Meat Quality

International Journal of Poultry Science. 18 (6) 249-254. p. ISSN: 1682-8356, DOI:10.3923/ijps.2019.249.254.

2.

Drobnyák, Á.; Bódi, L; Heincinger, M.; Kustos, K.; Szalay, I.T.; Almási, A.; Zimborán, Á.É.; Szabó, R.T.; Weber, M. (2019): The effect of crossing of Yellow Hungarian chicken breed with different commercial lines on meat production and meat quality

Bulgarian Journal of Agricultural Science, 25 (6), 1281–1286
ISSN: 2534-983X,

International conferences

1.

Drobnyák, Á; Szabó, RT; Bódi, L; Kustos, K; Almási, A; Liptói, K; Weber, M; (2018):

Egg parameters of two Hungarian indigenous chicken breeds

In: Estella, Prukner-Radovcic; Helga, Medic - Estella, Prukner-Radovcic; Helga, Medic (szerk.) Worlds'Poultry Science Journal: The XVth European Poultry Conference, Conference Information and Proceedings

Dubrovnik, Horvátország: World's Poultry Science Association (WPSA), p. 466, 1 p.

2.

Drobnyák, Árpád; Skrobár, Szonja Csenge; Szabó, Rubina Tünde; Kustos, Károly; Heincinger, Mónika; Zimborán, Ágnes; Bódi, László; Weber, Mária; (2017)

Hússzín- és porhanyóosság-vizsgálatok kendermagos magyar tyúkkal kialakított keresztezésekben pp. 27-27.

In: Bényi, E; Bodnár, Á.; Pajor, F.; Póti, P. (szerk.) 6th Scientific Day of Animal Breeding in Gödöllő - International Conference; VI. Gödöllői Állattenyésztési Tudományos Nap - Nemzetközi Konferencia: Book of abstracts of presentations and posters; Előadások és poszterek összefoglaló kötete

Gödöllő, Magyarország: Szent István Egyetem Mezőgazdaság- és Környezettudományi Kar, p. 71

3.

Drobnyák, Árpád; Skrobár, Szonja Csenge; Szabó, Rubina Tünde; Kustos, Károly; Heincinger, Mónika; Zimborán, Ágnes; Bódi, László; Weber, Mária (2017): Vágási paraméterek és húsminőség vizsgálata sárga magyar tyúkra alapozott keresztezésekben pp. 28-28.

In: Bényi, E; Bodnár, Á.; Pajor, F.; Póti, P. (szerk.) 6th Scientific Day of Animal Breeding in Gödöllő - International Conference; VI. Gödöllői Állattenyésztési Tudományos Nap - Nemzetközi Konferencia: Book of abstracts of presentations and posters; Előadások és poszterek összefoglaló kötete Gödöllő, Magyarország: Szent István Egyetem Mezőgazdaság- és Környezettudományi Kar, p. 71

4.

Balogh, S; Heincinger, M; Szabó, RT; Bódi, L; Drobnyák, Á; Kustos, K; Weber, M; (2015):

Alternatív keresztezések tojásvizsgálata

In: Bényi, E; Pajor, F; Póti, P; Tózsér, J (szerk.) V. Gödöllői Állattenyésztési Tudományos Napok Nemzetközi Konferencia Gödöllő, Magyarország: Szent István Egyetem Mezőgazdaság- és Környezettudományi Kar,

5.

Drobnyák, Á; Heincinger, M; Kustos, K; Szalay, I; Bódi, L; Szabó, R; Lan, Phuong TN; Weber, M (2015):

Comparing meat quality and production of F1 crossbreds between Speckled Hungarian chicken breed and two intensive chicken breeds

In: Szalay, István; Kisné, Do thi Dong Xuan (szerk.) Agrobiodiversity Protection and Conferenc: 8th Hungarian-Vietnamese Symposium

Gödöllő, Magyarország: Haszonállat-génmegőrzési Központ, p. 8

Hungarian conferences

1.

Drobnayák, Árpád; Skrobár, Szonja Csenge; Szabó, Rubina Tünde; Kustos, Károly; Heincinger, Mónika; Almási, Anita; Zimborán, Ágnes; Bódi, László; Weber, Mária (2018):

Termelési és húsminőség vizsgálatok eredményei sárga magyar tyúkra alapozott keresztezésekben

In: Irinyiné, Oláh Katalin; Tóth, Csilla - Őshonos- és Tájfajták - Ökotermékek - Egészséges táplálkozás - Vidékfejlesztés: Minőségi élelmiszerek - Egészséges környezet: Az agrártudományok és a vidékfejlesztés kihívásai a XXI. században

Nyíregyháza, Magyarország: Nyíregyházi Egyetem Műszaki és Agrártudományi Intézet, pp. 86-87., 2 p.

2.

Drobnayák, Árpád; Végi, Barbara; Szabó, Rubina Tünde; Bódi, László; Kustos, Károly; Kissné, Váradiné Éva; Almási, Anita; Liptói, Krisztina; (2018):

Kendermagos magyar tyúkra alapozott keresztezések szaporodásbiológiai vizsgálata

In: Irinyiné, Oláh Katalin; Tóth, Csilla - Őshonos- és Tájfajták - Ökotermékek - Egészséges táplálkozás – Vidékfejlesztés: Minőségi élelmiszerek - Egészséges környezet: Az agrártudományok és a vidékfejlesztés kihívásai a XXI. században

Nyíregyháza, Magyarország: Nyíregyházi Egyetem Műszaki és Agrártudományi Intézet, pp. 46-47., 2 p.

3.

Drobnayák, Árpád; Kustos, Károly; Szabó, R.T.; Heincinger, Mónika; Bódi, László; Petruska, Evelin; Weber, Mária; (2016):

Tojánhéjminőség vizsgálata őshonos tyúkfajtákból létrehozott keresztezési konstrukcióknál p. 62, 1 p.

In: Szalka, Éva; Bali, Papp Ágnes (szerk.) XXXVI. Óvári Tudományos Nap - Hagyomány és innováció az agrár- és élelmiszergazdaságban: Tudományos Nap Összefoglalók
Mosonmagyaróvár, Magyarország: Széchenyi István Egyetem Mezőgazdaság- és Élelmiszertudományi Kar,

4.

Drobnyák, Árpád.; Szabó, Rubina Tünde; Bódi, László; Pap, Tibor; Zimborán, Ágnes; Kustos, Károly; Weber, Mária; (2016):

Vedletett és nem vedletett őshonos tyúkfajták tojánhéjminőségének összehasonlítása

In: Tóth, Csilla (szerk.) Őshonos- és tájfajták - Ökotermékek - Egészséges Táplálkozás - Vidékfejlesztés: A XXI. század mezőgazdasági stratégiái

Nyíregyháza, Magyarország: Nyíregyházi Egyetem Műszaki és Agrártudományi Intézet, pp. 45-45., 2 p.

5.

Kissné, Váradi Éva; Drobnyák, Árpád; Végi, Barbara; Liptói, Krisztina; Barna, Judit; (2016):

Őshonos tyúkfajták keresztezés utáni termékenység vizsgálata

In: Tóth, Csilla (szerk.) Őshonos- és tájfajták - Ökotermékek - Egészséges Táplálkozás - Vidékfejlesztés: A XXI. század mezőgazdasági stratégiái

Nyíregyháza, Magyarország: Nyíregyházi Egyetem Műszaki és Agrártudományi Intézet, pp. 159-166., 7 p.

6.

Végi, Barbara; Drobnyák, Árpád; Váradi, Éva; Liptói, Krisztina; Barna, Judit (2016):

Őshonos és intenzív húshasznú tyúkfajták ondóminőségének összehasonlítása

In: Tóth, Csilla (szerk.) Őshonos- és tájfajták - Ökotermékek - Egészséges Táplálkozás - Vidékfejlesztés: A XXI. század mezőgazdasági stratégiái

Nyíregyháza, Magyarország: Nyíregyházi Egyetem Műszaki és Agrártudományi Intézet, pp. 229-235.