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The effect of the crossing of Yellow Hungarian chicken breed with different commercial lines on meat production and meat quality

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Abstract

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In the recent decades, new customer preference has appeared in the market for better quality and non-intensive products. The crossbred genotypes, based on old Hungarian breeds, can play the main role in the quality production and participate in gene conservation.

The aim of this study was to establish and compare the meat production and meat quality of purebreds (Yellow Hungarian breed (YH), TETRA-H (T), TETRA HARCO (H)) and their crossbreds. 160 birds of each genotype were raised in same condition and were slaughtered at the age of 84 days.

The T x YH (2480 g) and YH x T (2276 g) groups had a significantly higher live weight than the purebred YH (1580 g) genotype. The live weight of T and YH genotypes in both combinations were even significantly higher than the weight of H x YH (1656 g) and YH x H (1677 g). The results were similar in cases of carcass weight, breast fillet weight and leg weight. No significant differences were found in carcass percentage. The breast fillet rate of the YH x T genotype and YH were 17% and 14% respectively and valuable meat parts were 52% and 48%. In the case of pH values, considerable differences were not established. The breast meat of YH x H had more redness (4.52) than T x YH (1.28) and YH x T (1.58) genotypes. The YH (2.04 kg) has smaller shear force value than T x YH (3.23 kg) and H x YH (2.99 kg).

According to the results, the meat production of crossbreds was better than that of YH purebred. The meat production of crossbred genotypes was more favourable than the production results of purebred YH, but the meat quality parameters were not changed.

Keywords: reciprocal cross; genotype; meat quality; Yellow Hungarian; carcass percentages; breast pH; tenderness

Introduction

Modern hybrids are highly suitable for commercial production. However, quality, environmental and animal welfare issues have led to significant consumer demand for products of higher quality, non-intensive production on the market (Hoffmann, 2005). During breeding, the genetic stock collapsed and biodiversity has also reduced notably (Tisdell, 2003). Due to their lower production, indigenous breeds have apparently lost their significance, and their maintenance is largely carried out in gene banks. Old Hungarian chickens have been generally kept extensively. Therefore, these breeds have many beneficial properties such as toughness, persistence to pathogens, vigorous temperament and have favourable meat quality. These traits enable their free-range keeping (Szalay, 2002; Szalay, 2015). In addition, to preserve these genotypes, researchers have to make every effort to determine their practical uses (Sófalvy & Vidács, 2002).One method for this is to apply different crossing constructions. In previous studies, various crossings with the Yellow Hungarian breed were developed and their meat production and meat quality were tested (Konrád et al., 2007; Konrád & Kovácsné Gaál, 2008), but foreign crossing partners were used in the experiments (redbro, hubbard flex, shaver farm, S 77).

The slaughter ages of slow-growing chicken breeds vary from 56 to 84 days (Fanatico & Born, 2002; Yang & Jiang, 2005).

The meat quality of slaughtered broilers is determined by several factors. Meat quality refers to all the physical, chemical, and biological properties, formed after the slaughtering. The main properties of the meat quality: colour, texture, flavour, taste and functionality (Fletcher, 2002).

The consumer preference in the area of meat quality, especially the colour, is not easy to be established. It depends on culture, region and personal attitude (Kennedy et al., 2005). According to the studies, the pale tan or pinkish (Kennedy et al., 2005), pale tan to pink (Fletcher, 2002), pale pink (Nortcutt, 2009) colour of raw meat were preferred by consumers.

Fletcher (1999) found that the lightness value (L*) range was 43.1 -48.8 in five commercial broiler processing plants. In a previous investigation has been compared the broiler (CP707) and Thai indigenous chicken breast colour. There were significant differences between the commercial broiler and Thai indigenous chicken in case of lightness values L* (38.79 vs. 42.33) and yellowness values b* (3.62 vs. 4.75), but the redness values a* (-0.09 vs. -0.06) did not differ significantly (Wattanachant et al., 2004). According to the result of Berri et al. (2001) the selection to bigger live weight and breast yield led to more lightness in breast meat.

Tenderness is one of the most important features of the processed meat (Fletcher, 2002). Wattanachant et al. (2004) found significant differences between the shear force values of broiler and Thai indigenous chicken (0.78 kg vs. 4.09 kg). Miller et al. (2001) reported, the meat, which has less than 3 kg shear force value, is considered as tender

Authors have found strong relation between meat quality and slaughter weight (Janisch et al., 2011; Baéza et al., 2012; Yalcin & Güler, 2012). Yalcin et al. (2014) established that the pH value of breast meat, 24 hours after the slaughtering (pH24) depends on the slaughtered weight. The pH24 of broilers, with 1800 – 2100 g body weight was higher than those with 2400 g. Broilers slaughtered at weight of 1800 g had higher L* values than 2100 and 2400 g broiler birds. Neither breeder age nor slaughter weight had an effect on breast meat redness (a*), yellowness (b*) and texture values.

During the selection of the broiler chickens, the formation of larger breast meat was emphasized. However, the increasing in the muscle weight is negatively correlates with the amount of stored glycogen. The decreasing glycogen levels result higher *post-mortem* pH (Webb & Casey, 2010). Swatland (2008) clearly demonstrated that low and high *post-mortem* pH causes meat deficiency and affects the colour of meat.

The purpose of the present study investigating and comparing the meat production and quality parameters of Yellow Hungarian chicken as well as their crossbreds from the crosses with 2 commercial grandparent lines of TETRA-H and TETRA HARCO.

Materials and Methods

Experimental design and bird management

The experiment was authorized by the Directorate of Food Safety and Animal Health of Governmental Office of Pest County (Licence number XIV-I-001/1880-5/2012).

40 animals per genotypes (4 replicate groups) were applied to determine the meat production and meat quality parameters in all genotypes.

Chickens were investigated in seven groups: four crossbred groups by reciprocal crossings and 3 purebred groups (Yellow Hungarian, YH) chickens and grandparent lines of TETRA-H (T) and TETRA HARCO (H). The labels of studied groups are showed in Table 1.

Table 1. The genotype of different crossing constructions

Genotype of crossing	Crossing construction	
	Sire	Dam
TxYH	TETRA-H (T)	Hungarian yellow (YH)
YHxT	Hungarian yellow (YH)	TETRA H (T)
HxYH	TETRA HARCO (H)	Hungarian yellow (YH)
YHxH	Hungarian yellow (YH)	TETRA HARCO (H)
YHxYH	Hungarian yellow (YH)	Hungarian yellow (YH)
TxT	TETRA-H (T)	TETRA-H (T)
HxH	TETRA HARCO (H)	TETRA HARCO (H)

The groups were compared as:

• YHxYH to YHxT, TxYH, YHxH, HxYH,
• TxT to YHxT, TxYH,
• HxH to YHxH, HxYH,
• and the crossed group with each other.

Feed content varied with age and it is shown by Table 2. All birds received wing tags and were raised under similar conditions in the same building in 28 separated pens (7 genotypes, 4 pens/genotype, 40 birds/pen 5 birds/m^2). The floor was covered with straw shaving. All birds were given an initial 23 h photoperiod, then a 16 hour light: 8 hours dark lighting schedule from 8 days of age was provided. The temperature was maintained at 32°C at the beginning of the experimental period and gradually decreased to 20°C by the fourth week of age. No health problems were observed during the experiment.

Table 2. Nutrient contents of diets

Ingredients	Age		
	0-3 (weeks)	4-6 (weeks)	7-12 (weeks)
Crude protein (%)	23.3	20.0	17.5
ME (MJ/kg)	12.1	11.9	12.6
Crude fibre (%)	3.7	3.9	3.4
Crude ash (%)	5.8	5.8	5.7
Methionine (%)	0.6	0.4	0.4
Lysine (%)	1.2	1.1	0.9
Calcium (%)	0.9	1.0	1.0
Phosphorus, available	0.2	0.2	0.2

Sampling and Measurements

The growing period has taken 84 days. The slaughter was done in a slaughterhouse under the same commercial conditions in the case of all groups. Before the transport (1 hour) to the slaughterhouse, an 8-hour-long feed withdrawal was used. After slaughtering and evisceration, the carcasses were cooled for 2 hours at 4°C.

Live weight (LW) was measured immediately before slaughter in the slaughterhouse, and the carcass weight (CW) was determined after chilling. After chopping and filleting, the weight of the breast (BFW) and leg (LeW), the pH (pH1) and breast colour were measured. The samples were individually packed in plastic bag and transported to the laboratory in ice-cooled boxes for further measurements. The breast pH (pH2) and colour were established again after the slaughter, followed by a 24-hour refrigerated storage (4°C).Carcass percentage (C% = (CW/LW) x 100 and valuable meat part percentages (VMP% = (BFW + LeW)/CW x 100) were calculated.

ApH-STAR Matthäus® pH meter (Matthäus GmbH & Co.,Eckelsheim, Germany) was used for determining the exact pH values. The colour of the meat samples was determined by a reflectance spectrometry with the Minolta® CR 410 (Konica Minolta INC., Tokyo, Japan) Chromameter. The colour measurements were performed in the CIELab L*a*b* colour system (L*: 0 = black, 99 = white, a* – + red, – green, b * – + yellow, – blue) on the fresh meat surface. The breasts were stored for one month (20°C) then were thawed at room temperature. After thawing, the samples were grilled in a contact grill (Philips Cucina HD 2430, Hamburg, Germany). The meat samples were treated on a core temperature of 72°C and monitored with a core thermometer (TESTO 926, TESTO AG, Lenzkirch, Germany) placed in the centre of the breast fillets. The prepared samples were cooled to room temperature. The shear force values of the breast samples were obtained with TA.XT PLUS (Stable Micro Systems, Godalming, United Kingdom) equipment. A 1.2 mm thick Warner-Bratzler blade was fixed to the unit, which passed through the specimens with a linear, permanent motion of 250 mm/min. Samples were positioned so that the blade was perpendicular to them. The maximum shear force values were selected by the Texture Exponent 32 (Stable Micro Systems, Godalming, United Kingdom) program which can display the force/time (kg/s) graphs.

Statistical analysis

Statistical evaluation of the results was carried out by using R 3.1.1. program. All variables were checked for normality (Shapiro-Wilk test). Values are presented as means ± S.D. One-way ANOVA was performed at $p \leq 0.05$ significance level. Tukey post hoc test was applied for comparison between control and treatment groups.

Results

Table 3 shows the results of meat production parameters of different genotypes. TxT group was significantly heavier than TxYH and YHxT crossbreds' genotypes ($p \leq 0.001$, $p \leq 0.001$).

Table 3. The results of the meat production parameters of crossed Yellow Hungarian

Genotypes		LW[1]	CW[2]	BFW[3]	LeW[4]	C%[5]	BFW%[6]	LeW%[7]	WMP%[8]
		g	g	g	g	in carcass %			
TxYH	Mean	2481^{bB}	1773^{bB}	280^{bB}	60^{bB}	71	16^{B}	34	50^{B}
	SD	258	189	42	69	0.93	1.30	1.36	1.28
YHxT	Mean	2277^{bB}	1642^{bB}	277^{bB}	569^{bB}	72	17^{b}	35	52^{b}
	SD	246	169	31	63	6.40	1.95	3.57	5.13
HxYH	Mean	1657^{a}	1171^{a}	162^{a}	404^{a}	71	14	35	48
	SD	244	190	36	67	1.66	1.90	1.11	2.29
YHxH	Mean	1678^{a}	1206^{a}	174^{a}	414^{a}	72	14	34	49
	SD	152	113	27	41	2.45	1.35	2.21	2.89
YHxYH	Mean	1578^{a}	1101^{a}	155^{a}	375^{a}	70	14^{a}	34	48^{a}
	SD	143	104	22	37	1.36	1.18	1.26	1.39
TxT	Mean	3109^{A}	2332^{A}	430^{A}	814^{A}	75	18^{A}	35	53^{A}
	SD	386	305	86	99	2.06	1.67	1.31	1.38
HxH	Mean	1618	1164	167	410	72	14	35	50
	SD	90	59	18	20	0.88	1.30	0.79	0.88

1: Live weight; 2: Carcass weight; 3: Breast filet weight; 4: Leg (Thigh+Drumstick) weight; 5: Carcass weight/Live weight*100;6: Breast filet weight/Carcass weight*100;7: Leg (Thigh+Drumstick) weight/Carcass weight*100; 8: Breast filet weight + Leg (Thigh+Drumstick) weight/Carcass weight*100
a,b: different superscript letters show significant differences ($p \leq 0.05$) between YHxYH and TxYH, YHxT, HxYH, YHxH in a column detected by Tukey-test
A, B: different superscript letters show significant differences ($p \leq 0.05$) between TxT and TxYH, YHxT genotypes in a column detected by Tukey-test

Furthermore, these two crossings had significantly higher live weight than the pure breed YH ($p \leq 0.001$, $p \leq 0.001$) group. Comparing the crossings, the TxYH and YHxT groups had a higher live weight than the other two crossings which involved the H (HxYH ($p \leq 0.001$, $p \leq 0.001$) and YHxH ($p \leq 0.001$, $p \leq 0.001$)). There were no significant differences among the live weight of the latter two groups and Yellow Hungarian breed. Carcass weight had similar differences than live weight. Although there were differences in live and carcass weight, in the case of carcass percentages no differences were established.

Breast fillet/carcass weight ratio of the YHxT genotype was significantly higher than the YH ($p \leq 0.001$), but in TxYH was lower than in TxT ($p \leq 0.001$) genotype. There were no significant differences in the leg weight (thigh+

Table 4. The result of meat quality of crossed Yellow Hungarian

Group		pH1[1]	pH2[2]	Breast colour						Tenderness, kg
				after the chilling to 4°C			24 hours after slaughter			
				L*[3]	a*[4]	b*[5]	L*[3]	a*[4]	b*[5]	
TxYH	Mean	5.70	5.51	52.25	1.28^{b}	7.71	53.94	1.02	9.05	3.23^{b}
	SD	0.08	0.37	2.84	1.22	1.69	1.71	0.54	1.76	0.55
YHxT	Mean	5.73	5.72	50.88	1.58^{b}	8.66	55.15	-1.33	7.98	2.84
	SD	0.10	0.16	1.85	1.04	1.52	2.79	0.79	1.94	0.75
HxYH	Mean	5.71	5.63	52.49	1.83^{B}	8.54	62.35	3.18	14.21	2.99^{b}
	SD	0.07	0.02	2.46	0.99	1.92	6.92	3.51	4.89	0.67
YHxH	Mean	5.75	5.65	51.67	4.52^{a}	9.09	66.85	-0.54	11.58	2.73
	SD	0.08	0.04	2.68	4.02	2.74	1.46	1.93	2.46	0.52
YHxYH	Mean	5.75	5.73	52.98	2.16	8.27	54.35	2.46	9.28	2.04^{a}
	SD	0.16	0.32	3.15	1.42	1.98	4.33	2.01	0.98	0.58
TxT	Mean	5.73	5.81	49.08	0.98	6.16	59.18	2.32	11.74	2.93
	SD	0.15	0.19	3.28	1.94	1.20	7.95	1.16	5.15	0.59
HxH	Mean	5.66	5.62	52.35	0.85^{A}	8.07	54.24	0.54	11.32	3.48
	SD	0.09	0.07	2.95	1.46	1.71	2.85	0.84	2.63	0.54

1: after the chilling to 4°C, 2: 24 hours after slaughtering, 3: lightness (L*: 0 = black, 99 = white), 4: redness (- + red, – green), 5: yellowness (- + yellow, – blue),
a, b: different superscript letters show significant differences ($p \leq 0.05$) between YHxYH and TxYH, YHxT, HxYH, YHxH in a column detected by Tukey-test
A, B: different superscript letters show significant differences ($p \leq 0.05$) between HxH and HxYH, YHxH genotypes in a column detected by Tukey-test

drumstick) carcass weight rate among the genotypes. The results of breast fillet weight+leg weight (thigh+ drumstick)/ carcass weight were the same as the breast fillet weight/ carcass weight rate. The breast and the leg weight/carcass weight of YHxYH was significantly lower than YHxT ($p = 0.0382$) and the TxYH was also lower than TxT ($p = 0.0317$). No differences were found between the YHxT and TxYH genotypes in the examined parameters.

The meat quality properties are given in Table 4.

The YHxH and YHxYH groups had the highest pH1 values and the HxH genotypes had the lowest. However, no statistical differences were found between the different genotypes at the pH values measured at different times after the slaughter.

There were several significant differences established in the case of breast colour. Significant differences were found among crossbred genotypes in the case of a*, the TxYH, YHxT had lower value than the YHxH ($p = 0.009$, $p = 0.0246$). Furthermore, the HxYH had higher a* value than HxH ($p = 0.0019$). There were no differences according to in the breast colour (L*,a*,b*) among the genotypes24 hours after the slaughter.

YH had lower shear force values than the TxYH ($p \leq 0.001$) and HxYH ($p = 0.014$) genotypes. No significant difference was found between the crossbred genotypes in the tenderness.

Discussion

In this study meat production and meat quality of four crossings of Yellow Hungarian chickens and three purebred genotypes were compared. The slaughter weight of chickens in the conventional production system is 2-2.5 kg. Fast growing genotypes attain this weight in 40-45 days, but slow- and medium-growing genotypes require 63-81 days (Gordon & Charles, 2002). The slow-growing genotypes are more widespread in Asia; slaughtering age of these genotypes is 100-120 days (Yang & Jiang, 2005; Tang et al., 2009; Wang et al., 2009). Promket et al. (2016) described native chicken breed (Chee) in Thailand with long (84 days) slaughter period. In this study, the Yellow Hungarian attained 1578 g live weight at 84 days of age, thus this breed belongs to the slow-growing chickens. Wang et al. (2009) investigated the slow-growing local chicken (Gushi) which has 1611 g live weight at the age of 112 days, similarly to our results in Yellow Hungarian, but their growing period was shorter. Tang et al. (2009) investigated the Lingnanhuan, which is a Chinese commercial broiler line. It was synthesized from layer line, local breeds and exotic broiler by the Institute of Animal Science, Guangdong Academy of Agricultural Sciences (Guangzhou, China). The Lingnanhuan breed reached the 1689 g live weight at the age 56 days, which is similar to the results of HxYH (1657g) and YHxH (1678g) genotypes, but it is lower than the live weight of TxYH (2481g) and YHxT (2277g) genotypes. However, the growing period of Lingnanhuan was shorter with 28 days than in this study. The differences showed the same trend: Lingnanhuang (1039g), HxYH (1171g),YHxH (1206g),TxYH (1773 g) and YHxT (1642 g). The carcass percentages of the Gushi breed at age of 112 day was 69.9% (Wang et al., 2009), it is comparable with the percentage of the Yellow Hungarian (70%). Konrad et al. (2007) created crossbreds with the Yellow Hungarian as a dam and different meat type hybrids assires. Among these genotypes, the Yellow Hungarian x Hubbard flex has the highest live weight (2193 g), this result is similar for TxYH (2481 g) and YHxT (2277 g) crossbreds. Different results are shown in the live weight of the Yellow Hungarian (1031 g, Konrad et al. (2007) vs. 1578 g in this study). Konrad et al. (2007) found that the breast fillet weight/carcass weight of the Yellow Hungarian was 23.6%, it is substantially higher than the result of this investigation (14%). However, and these differences were not found in case of leg weights (34.9% vs. 34%).

Yamak et al. (2014) demonstrated that pH (at 24 h *post mortem*) was significantly different in breast of chickens with live weight of 1800 g and 2400 g. Even so, measured values of pH24 in different live weight chickens (YHxYH vs. TxYH and YHxT) did not vary in this study. Weber et al. (2008) investigated the old Hungarian chicken breeds, including Yellow Hungarian, and ROSS 308 hybrid and did not find differences in the case of tenderness (Yellow Hungarian 2.67 kg vs. ROSS 308: 2.5 kg). Therefore, the breast of the Yellow Hungarian seemed to be tender (2.04 kg), but the values of TxYH (3.23 kg) and HxYH (2.99 kg) genotypes approached the 3 kg tender limit. Konrad & Kovácsné (2008) found that lightness of breast meat of Yellow Hungarian was lower (L* = 60.72) than result in this study (L* = 82.98), but the lightness of the leg meat was approximately similar (L* = 54.72 vs. 54.35). Debut et al. (2003) observed colour difference between a slow-growing line and fast-growing standard broiler line, the fast-growing birds (52.82) had lighter breast meat than the slow-growing birds (50.76).

Conclusion

Marketable live weight and good meat production can be produced by the crossings (TxYH, YHxT) from Yellow Hungarian and TETRA H. The crossings in the formation, of which the H genotype was involved, did not have a better meat production.

Of the crossed genotypes, the YHxH group was redder than the TxYH and YHxT genotypes after the slaughter. These differences disappeared after 24 hours of refrigerated storage. In the parameters of meat quality, there are no consequent; therefore, outstanding genotype cannot be established. The meat quality parameters of Yellow Hungarian and TxYH and YhxT did not differ.

For these reasons the TxYH and the YHxT genotypes are recommended for further investigation and for extensive or semi-extensive production.

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