Slaughter yield and meat quality of chicken at different length of preslaughter feed withdrawal

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Schlachtleistung und Fleischqualität von Masthühnern bei unterschiedlicher Dauer des Futterentzuges vor der Schlachtung

1 Introduction

In the European Community, per-head consumption of chicken meat is steadily rising. Many consumers attempt eating more healthy products (BICKEL and WETSCHEREK, 2005) and that is why chicken meat with its low fat content is often preferred to beef or pig meat. Also events like the BSE-crisis or abuse of antibiotics in pig production, which are very present in the media, might lead the customers towards chicken meat. Nowadays quality is a major concern for most of the consumers, especially when buying foods.

The most important factor in chicken meat quality is prevention from microbial contamination. Feed withdrawal before slaughter is a known procedure to lower the risk of contamination with faeces prior to slaughter, and the emptied intestinal tract also decreases the incidence of contamination of meat during dissection. Thus, feed withdrawal before slaughter in broiler production is a matter of recent research (e.g. SENGOR et al., 2006; KIM et al. 2007). Feed withdrawal prior to slaughter is also often caused by long transport times from the producer to the slaughterhouse. A further side effect of starving before slaughter is reducing the amount of waste material, which lowers disposal costs.

Zusammenfassung

180 Masthühner wurden in 6 Schlachtgruppen unterteilt und mit 0, 2, 4, 8, 16 oder 24 Stunden Futterentzug vor der Schlachtung behandelt. Die Tiere wurden stressfrei und ohne Transport oder Wartezeiten geschlachtet. Gemessen wurden diverse Schlachtkörpergewichte, pH-Werte nach der Schlachtung und nach 24 Stunden, sowie verschiedene Blutparameter (Triglyzeride, Totalprotein, Albumin, Glutamatdehydrogenase und Aspartat-Aminotransferase). Gegrillte Fleischproben wurden durch ein Team professioneller Verkoster sensorisch untersucht. Mit steigender Futterentzugszeit reduzierte sich das Schlachtgewicht, und zwar hauptsächlich beim Brust- und Schenkelfleisch. Beide pH-Werte wurden leicht angehoben, allerdings nicht genug, um DFD-Fleisch zu forcieren. Die Verkoster benoteten das Fleisch von Tieren mit längerer Nüchterungszeit etwas positiver.

Schlagworte: Fleischqualität, Futterentzug, Masthühner, pH, Schlachtleistung.

Summary

180 broilers were divided into 6 groups, which were withdrawn from feed for 0, 2, 4, 8, 16 or 24 hours before slaughter. Slaughter took place without any stress caused by transport or waiting times. Data about various slaughter weights, pH-values directly after slaughter and after 24 hours and various blood parameters (triglycerides, total protein, albumin, glutamate dehydrogenase and aspartate aminotransferase) were collected. Grilled meat samples were examined by a professional tasting panel. Increasing length of feed withdrawal reduced carcass weight, mainly due to losses in breast and thigh meat. Both pH-values rose slightly, but not sufficient to promote the development of DFD-meat. The tasting panellists preferred meat samples from animals with longer time of feed withdrawal.

Key words: Broilers, feed withdrawal, meat quality, pH, slaughter performance.

Therefore the present study aimed at the influence of preslaughter feed withdrawal on various quality traits of chicken meat.

2 Materials and Methods

2.1 Animals and Growing

This study employed 180 newly hatched male and female (1:1) broilers from the hybrid line Ross. They were divided into 12 groups, each containing 15 animals. Each group was kept in pens of 2 m^2 of size. Ground material consisted of wood shavings. A lighting program provided a daily light cycle of 23 hours during the first week, of 22 hours during the second and of 21 hours until the end of the study. Ventilation was supported by 2 air vents, which were connected to infrared lamps to maintain a constant temperature inside the building. Ambient temperature was set at 27 °C during the first week, 23 °C during the second week and 20 °C from 3rd week until end of study.

Three different diets were used. During the first 9 days the chicks received 0.36 kg of a starter mix (12.35 MJ ME, 22.5 % XP). The next 16 days 1.7 kg grower diet was fed (12.80 MJ ME, 21.5 % XP), and the finishing diet (12.90 MJ ME, 21 % XP) was fed during the last 10 days of the experiment at an amount of 1.55 kg per day.

Slaughter took place at experimental day 36 between 9 and 10 a.m. Relative to this time point, feed was withdrawn from the pens according to a time schedule producing a duration of starving of 0, 2, 4, 8, 16, or 24 hours. Each of these 6 levels of feed withdrawal was represented by 2 pens (30 animals). Access to water, which was provided at libitum during the experimental period, was also prevented from time point of feed withdrawal until slaughter. During slaughter, special attention was paid not to stress the animals in order to exclude side effects on meat quality other than feed withdrawal. Animals were taken out of their pens and immediately stunned by a hit on the back head and exsanguinated.

2.2 Measurements

Animals were weighted on day 1, 21, 35 and immediately before slaughter on day 36. After exsanguination the carcass weight was measured. Next, the birds were scalded at 55 °C before they were put into a feather picking machine. The evisceration was done by hand followed by the measurement of the warm eviscerated weight (carcass weight without feathers, digestive tract, inner organs and abdominal fat pad). Heart, liver, stomach and abdominal fat pad weights were determined separately. After 24 hours of cooling storage at 3 °C the cold eviscerated weight and, after separation of head, neck and feet, the oven-ready weight were measured. From each slaughter group, 6 male and 6 female birds ranging most close to the mean value of warm eviscerated weight were selected for further dissection and determination of weight of head and neck, feet, thighs, breast, wings and rest of carcass.

Breast muscle pH was measured immediately after slaughter and after 24 hours of cooling storage (pH_1 and pH_{24}). Blood plasma retrieved from blood collected during exsanguination was analyzed for total protein, albumin, triglycerides and the liver enzymes glutamate dehydrogenase (GLDH) and aspartate aminotransferase (AST) at the laboratories of the University of Veterinary Medicine, Vienna, using standard blood chemistry procedures. Meat samples from breast and tight of animals submitted to 0, 2, 8, 16 or 24 hours feed withdrawal were pooled within treatment group and tested by a professional tasting panel (25 persons) for sensorial meat quality (toughness, juiciness and taste). At first, meat samples were scored for felt quality between 1 (best) and 5 (worst). The second step was to express the fulfilment of expectations towards the properties of the meat samples (100 % = complete fulfilment of expectation).

2.3 Statistical Analysis

The statistical analyses were done using the program SAS (SAS INSTITUTE INC., 1999). The model used was a factorial ANOVA with interaction between slaughter group and sex. Means were compared using the Student-Newman-Keuls test. For all evaluations, differences between means were considered significant at $\rho \leq 0.05$.

3 Results

3.1 Live weight

At the end of day 35 (before the onset of feed withdrawal), mean live weight averaged 2230 g with only small variations between the 6 groups. Rising duration of feed withdrawal reduced preslaughter live weight from 2340 g (0 h feed withdrawal) to 2121 g (24 h feed withdrawal) (Table 1).

Table 1: Carcass and cut yield (g)
Tabelle 1: Schlacht- und Teilstückgewichte (g)

	Feed withdrawal time (h)						
	0	2	4	8	16	24	SD
Weight before slaughter [1]	2340	2348	2322	2201	2121	2121	
Carcass weight	2255 [a]	2268 [a]	2238 [a]	2121 [b]	2047 [b]	2050 [b]	264
Head and neck	92	88	91	87	89	92	10
Feet	77 [a]	67 [b]	66 [b]	64 [b]	63 [b]	63 [b]	13
Breast	450 [a]	446 [ab]	428 [ab]	423 [ab]	415 [ab]	408 [b]	48
Thighs	463	459	457	442	458	428	66
Wings	165	169	169	163	161	165	18
Rest of body	522	522	536	502	502	487	66
Eviscerated weight (warm)	1814 [a]	1831 [a]	1835 [a]	1752 [ab]	1702 [b]	1708 [b]	255
Abdominal fat pad	41.8 [ab]	43.3 [a]	39.9 [ab]	39.2 [ab]	38.7 [ab]	35.4 [b]	10.5
Heart	9.2 [a]	9.3 [a]	9.3 [a]	8.3 [ab]	8.2 [ab]	8.1 [b]	1.9
Liver	50.8 [a]	52.8 [a]	50.7 [a]	41.9 [b]	39.2 [b]	41.9 [b]	9.6
Stomach	22.4	20.8	21.1	22.6	21.6	21.6	3.7
Eviscerated weight (cold)	1781 [a]	1784 [a]	1773 [a]	1699 [ab]	1652 [b]	1656 [b]	211
Oven-ready weight	1609 [a]	1624 [a]	1614 [a]	1544 [ab]	1503 [b]	1503 [b]	191

[1] During the last day of growing, animals were treated by different times of feed withdrawal. Live weights were determined per group and therefore no parameters of statistics were calculated
[a,b] Means within columns with differing superscripts are significantly different ($p \leq 0.05$)

3.2 Slaughter yields

The effect of feed withdrawal on carcass and cut yield is given in table 1. Weight of the undissected carcass decreased markedly ($p < 0.05$) from 2255 g to 2050 g when feed withdrawal time was prolonged from 0 to 24 h. This effect was mainly caused by a decrease ($p < 0.05$) of breast weight of about 40 g. Feet weight decreased ($p < 0.05$) during the first two hours of feed withdrawal, whereas longer duration of starvation had no further effects. Warm eviscerated weight varied ($p < 0.05$) between 1835 g at 4 h feed withdrawal and 1702 g at 16 h feed withdrawal. The abdominal fat pad showed a slight but significant decrease in weight when time of feed withdrawal increased, comparable to the percentage amount of weight loss of the heart. The liver weighted between 51 and 53 g during the first 4 hours and then dropped ($p < 0.05$) rapidly to 39 to 42 g until 24 hours. Both, cold eviscerated weight and oven-ready weight developed in a manner comparable to warm eviscerated weight. Weight of head and neck, wings, rest of body and stomach was similar for all experimental groups. The difference in the weight of thighs between no feed withdrawal (463 g) and 24 hours of treatment (428 g) was noticeable, but, however, not statistically significant.

3.3 pH-values

Table 2 presents carcass pH-values measured directly after slaughter (pH_1) and after 24 hours of cooling storage (pH_{24}). The pH_1-value at 0 h of feed withdrawal was decreased ($p < 0.05$) compared to all other groups. The pH_{24}-value responded ($p < 0.05$) in a curvilinear manner to duration of feed withdrawal with a peak value of 6.05 at 16 hours.

Table 2: Breast muscle pH-values
Tabelle 2: pH-Werte im Brustmuskel

	Feed withdrawal time (in h)						
	0	2	4	8	16	24	SD
pH_1 [1]	6.27 [b]	6.45 [a]	6.45 [a]	6.48 [a]	6.48 [a]	6.50 [a]	0.29
pH_{24} [2]	5.78 [c]	5.77 [c]	5.88 [bc]	5.94 [ab]	6.05 [a]	5.88 [bc]	0.24

[1] pH_1 … pH immediately after slaughter
[2] pH_{24} … pH after 24 hours of cooling storage
[a,b] Means within columns with differing superscripts are significantly different ($p \leq 0.05$)

3.4 Blood parameters

The results of the blood parameter analysis are shown in table 3. Total protein after 8 and 16 h of feed withdrawal (3.00 g/dl) was lower ($p < 0.05$) than after 24 h of feed withdrawal (3.34 g/dl). On the other hand, albumin did not differ significantly between groups. The liver enzymes aspartate aminotransferase (AST) and glutamate dehydrogenase (GLDH) were both affected ($p < 0.05$) by length of feed withdrawal. AST increased from 336 to 415 U/L with longer feed withdrawal times, while GLDH decreased from 8.15 to 5.61 U/L with the lowest value at 16 hours (4.25 U/L) of feed off.

3.5 Sensory test

The tasting panel tended to prefer meat from animals with longer feed withdrawal, but in none of the 2 test situations differences between the slaughter groups reached level of significance. The Ranking sums decreased from 42 to 31 after 24 hours, while the test results for the fulfilment of expectations increased from 46 to 64 %.

4 Discussion

4.1 Live weight, carcass and evisceration yields

Feed withdrawal showed a significant impact on live weight, which was decreased by about 9 % between the 0 and 24 hours. BUHR et al., (1998) found a similar depression in live weight of 7.4 to 9.5 % at 24 hours of feed withdrawal. BENIBO and FARR (1985) and JENSEN et al. (1984) also found a comparable reduction of live weight. The difference between carcass weight and warm eviscerated weight leads to the conclusion that about half of the life weight loss is caused by the emptying gut. This corresponds well to the results of LYON et al. (1991). Nevertheless, besides the effects of reduced gut filling, weight reduction appears to be highly influenced by a weight loss of muscle tissue (Table 1). Thereby, weight reduction during such a short time span of feed withdrawal is mostly caused by a reduced water holding capacity, not by loss of fat and carbohydrates (LAWRIE, 1998). Most of the weight loss took place in the breast muscle, which was reduced by 42 g after 24 hours without feed in the present study. Comparable observations were made by BARTOV (1998), but the reduction in breast meat weight of 24 g after a 24 h feed withdrawal in this study was lower than in our experiment. Thigh meat also showed a considerable contribution to weight loss in the present study, but the decrease of 35 g was not significant. In accordance to DEMIR et al. (2004) the abdominal fat pad weight also decreased, but comparable to the thighs the differences between groups were not significant. The weight of the heart lost about 10 % ($p < 0.05$) after the animals were without feed for 24 hours. Another major weight loss occurred in the liver, which was reduced by about 20 %. TRAMPEL et al. (2005) found a weight loss of the liver of about 22 % after 12 hours of feed withdrawal. JENSEN et al. (1984) also reported liver shrinkage of 10 to 20 %, whereas BUHR et al. (1998) calculated between 13.6 and 26.5 %.

4.2 pH-values

Muscle pH-values are mainly dependent on the amount of glycogen stored in the muscles at the moment of slaughter. But there are also known differences in the pH-decrease between different muscles like breast or thighs (WARRISS et al., 1988). The pH-values in this study tended to rise slightly with increasing time of feed withdrawal, but a comparable trial from KOTULA and WANG (1994) revealed the opposite effect at least for the pH directly after slaughter. Depending

Table 3: Blood parameters
Tabelle 3: Blutparameter

	Feed withdrawal time (in h)						
	0	2	4	8	16	24	SD
Total protein (g/dl)	3.21 ^{ab}	3.15 ^{ab}	3.08 ^{ab}	3.00 ^{b}	3.00 ^{b}	3.34 ^{a}	0.40
Albumin (g/dl)	1.62	1.67	1.57	1.55	1.67	1.62	0.20
AST (U/L)	336 ^{b}	358 ^{b}	366 ^{ab}	324 ^{b}	370 ^{ab}	415 ^{a}	78
GLDH (U/L)	8.15 ^{a}	5.48 ^{b}	5.06 ^{b}	4.90 ^{b}	4.25 ^{b}	5.61 ^{b}	2.81
Triglycerides (mg/dl)	88 ^{a}	71 ^{b}	51 ^{c}	47 ^{c}	45 ^{c}	45 ^{c}	21

^{a,b} Means within columns with differing superscripts are significantly different (p ″ 0.05)

on the part of the carcass, the pH in this study was between 0.17 and 0.34 higher at 24 hours without feed than at 0 hours. After 24 hours of cooling storage, the pH values had reached similar levels throughout all groups. SAMS and MILLS (1993) reported that the pH rose between 0 and 5 hours of feed withdrawal, but there was no further increase at longer times of feed withdrawal. According to these authors muscle glycogen gets reduced as expected within short feed withdrawal times. At longer periods without feed, however, ATP is resupplied by fatty acid oxidation, and this process is much more efficient than glycolysis. Therefore the effects of feed withdrawal on pH-values become less visible. EDWARDS et al. (1999) found that the different slaughter techniques used in different studies might lead to such different results. Slaughter by cervical dislocation causes struggle and this alone can reduce the glycogen reserves by 23 percent. As an alternative they tested killing by a barbiturate overdose, which influenced the glycogen level only slightly.

The animals in the present study were protected from preslaughter stress situations like transport or loading and unloading from trucks. They were caught in the boxes, taken out and immediately slaughtered. It might be possible that preslaughter stress, as it occurs in the normal commercial production process, could result in more pronounced effects caused by feed withdrawal. DEBUT et al. (2003) investigated the effects of stress on final meat quality. They observed that preslaughter stress might cause higher final-pH-values, which could lead to PSE-like effects like reduced water-holding-capacity and pale colours.

Considering literature data, the increase in pH_1 and pH_{24} values due to a prolonged duration of feed withdrawal was, however, comparable low in the present study. Moreover, critical pH values normally associated with the development of DFD-meat appear to be higher than those observed in the present study. Thus, it may be concluded that the low influence of feed withdrawal without any preslaughter stress on pH values is not sufficient to cause an increase in pH-values associated to the development of DFD-meat.

4.3 Blood parameters

As expected, serum triglycerides decreased rapidly during the first two hours of feed withdrawal. In this time span, the fatty acids used for oxidation are obtained from triglycerides already circulating in blood, while the triglyceride reserves of fatty tissue are used later. HUFF et al. (1996) also found a very high decrease in blood triglycerides in turkeys and so did CASON and TEETER (1994).

Total protein and albumin were only marginally influenced by the length of feed withdrawal. This is in accordance to DEMIR et al. (2004) who observed a minimal increase of albumin from 1.17 to 1.23 g/dl after 16 hours of feed withdrawal in broiler chickens, while the total protein increased from 2.5 to 2.53 after 16 hours without feed. Thus, a major reduction of albumin is to be expected only after longer periods without feed. Nevertheless all these values remained within normal ranges for poultry.

Among the two liver enzymes examined in the present experiment, GLDH is only expressed in the mitochondria, while AST is found in the cytoplasm as well. These two parameters are normally used to check liver function and to confirm liver diseases. In accordance to literature (CASON and TEETER, 1994; DEMIR et al., 2004) AST increased during the withdrawal times, while GLDH decreased. Nevertheless both values also remained within normal ranges for poultry.

4.4 Sensory tests

The sensory test carried out in this study consisted of two parts. The first one was the ranking sum of felt quality, which showed a tendency to favour longer feed withdrawal times. The second test (fulfilment of expectations) turned out to numerically confirm the first test. In total, the sensorial properties of broiler meat tended to be improved by longer feed withdrawal times.

5 Conclusion

Duration of feed withdrawal does influence live weight (especially in breast and thigh meat) and therefore eviscerated carcass, which is very important for the producers, who are paid depending on the weight their animals reach.

It is possible that feed withdrawal has a negative effect on meat quality when it is combined with preslaughter stress, like loading and unloading, transport itself or waiting times at the slaughterhouse. The slight increase in pH values in the present study, however, appears to be too small to cause the development of DFD-meat.

Meat from animals with longer feed withdrawal times seemed to be favoured by the testing panel, although the differences were very small and not statistically significant.

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Eingelangt am 25. Juli 2006

Angenommen am 15. Oktober 2007