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The colour and texture of broiler breast meat related to different conditions of rearing and chilling

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ABSTRACT

The aim of the study was to establish the effects of chicken rearing conditions (the amount of ammonia in the air) and rate of chilling after slaughter on the variability of raw broiler breast colour and texture after thermal treatment. The dynamics of the post mortem decrease in pH value in the breast muscles (pectoralis superficialis) of chickens was also investigated. 160 chickens of Ross provenance were used in the experiment. The birds were divided into four groups subjected to different conditions of rearing and chilling. The results show that the effect of chilling on colour parameters of chicken breast meat, evaluated by means of technical instruments, was more substantial than the effect of rearing conditions. Chilling rate influenced the equipment-measured texture of chicken breast meat after thermal treatment. Glycolysis had not reached completion even six hours post mortem.
(Keywords: broiler, colour, texture, rearing, chilling)

ZUSAMMENFASSUNG

Einfluβ verschiedener Zucht- und Kühlbedingungen auf Farbe und Textur von Broiler-Brustfleisch

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Ziel der vorliegender Untersuchung war es festzustellen, welchen Einfluß die Zuchtbedingungen (die Konzentration des Ammoniaks in der Luft) sowie die Kühlbedingungen bei Broilern nach dem Schlachten auf die Farbe des rohen Brustfilets und seine Textur nach der thermischen Behandlung haben. Es wurde die Dynamik der post mortem pH-Wertverringerung im Masthähnchenfilet (pectoralis superficialis) gemessen. Objekt der Untersuchung waren hundertsechzig Broiler des Genotyps Ross. Die Tiere wurden hinsichtlich der Zucht- und Kühlbedingungen in vier Gruppen eingeteilt. Die Resultate beweisen, daß die Kühlbedingungen größeren Einfluss auf die Farbparameter (instrumental gemessen) haben als die Zuchtbedingungen. Die Kühlbedingungen haben auch einen signifikanten Einfluss auf die instrumental gemessene Textur nach der thermischen Behandlung. Die Glykolyse war sogar 6 Stunden nach dem post mortem noch nicht beendet.
(Schlüsselwörter: Masthähnchen, Farbe, Textur, Zucht, Kühlung)

INTRODUCTION

Colour and texture, primarily tenderness, are two of the main properties determining the quality and market acceptability of fresh thermally treated or processed poultry meat. Breast and fillet are the most preferred parts of the chicken for consumers as well as for producers, due to their pleasantly bright colour and good degree of tenderness and their low fat content. Unusually bright or dark colour of breast meat (fillet) and changed texture are the consequence of various pre-slaughter and post-slaughter factors (*Froning*, 1995). Dark colour of breast meat and firm texture occur in birds subjected to stress through struggling prior to slaughter and glycogen accumulation in muscles (*Ngoka* and *Froning*, 1982). Pre-slaughter handling causes PSE in muscles (*Babji et al*., 1982), apparent in a bright colour and soft water-like texture of breast meat that becomes firm and dry after thermal treatment (*Allen et al.,* 1997). Regardless of genotype or nutrition, the colour of poultry meat, especially dark colours, can be affected by the concentration of gases such as ammonia, carbon dioxide and carbon monoxide in cages or during transport to the slaughter house by unsuitable means of transport (*Sackett et al.,* 1986). Among the post mortem conditions, stunning (by means of electricity or CO_2), steaming before plucking and chilling of carcasses significantly affect the colour and texture of poultry meat (*Froning,* 1995). Chilling too rapidly can cause the firmness of muscles and dark colour that are also related to cold shortening of meat (*Locker* and *Hagyard*, 1963) but in contrast with red meat this does not deteriorate the colour or texture of poultry meat to such an extent.

The purpose of this study was to establish the effects of chicken rearing conditions (i.e., the amount of ammonia in the air) and rate of chilling after slaughter on the variability of raw broiler breast colour and texture after thermal treatment. The dynamics of the *post mortem* pH value decrease in the breast muscles of chickens was also investigated.

MATERIALS AND METHODS

Ross provenance broilers were included in this experiment. Non-sexed chickens were reared until 44 days of age. 160 chickens were divided into four groups: (i) reared in well aired cages and fast-chilled after slaughter; (ii) reared in well aired cages and slow-chilled after slaughter; (iii) reared in badly aired cages and fast-chilled after slaughter; (iv) reared in badly aired cages and slow-chilled after slaughter. The presence of ammonia was 5 ppm in the well aired cages and 31 ppm in the badly aired ones. This was measured by means of the *Dräger* model *ACCURO* with glass ampoules of *AMMONIA 5/b*, the measurement interval being ammonia quantity from 5 ppm to 100 ppm. The rate of air chilling was 2 hours at –2oC for fast chilling and 6 hours at 1oC for slow chilling. After slaughter pH_{45min} and $temperature_{45min}$ were measured in the *pectoralis superficialis* muscle (PS), after which the carcasses were chilled. The chilled carcasses (at approximately 5oC) were weighed and the weight of the breast muscles estimated. The raw breasts were assessed both by sensory techniques (for colour hue, colour uniformity and damage) and by instrument-based procedures (for L*, a* and b* values); pH_{3h} , pH_{6-8h}, $temperature_{45min}$ and $temperature_{6-8h}$ were measured and samples of breast were taken. The samples taken (24 hours after slaughter) were heated in an *MK AQUATERM 192095* heat-controlled water bath and after chilling assessed by an equipment-based method (for analysis of tenderness). Statistical analyses were performed using the *Statistical Analysis System* (*SAS,* 1990). The data obtained were analysed by the least squares method using the GLM procedure.

The sensory panel evaluated the colour hue of the samples with an analytical descriptive test using a scale of 1-3-5. Yellow hue was assessed at a score of 1, bright yellow at 2, suitably bright pink at 3, dark pink at 4 and dark hue on the surface of the fillet at 5. Colour uniformity and damage (to the breast, wings and thighs) were assessed. A system of scores of 1-7 or 1-3 was used, 1 signifying a trait not expressed, and 7 or 3 a significantly expressed trait. At the same time breast colour was analysed by means of a *Minolta CR b* chromometer (for L*, a* and b* values). L* value indicates the brightness of the sample (the higher the value the brighter the sample), a* shows the presence of red (the higher the value the redder the sample), and b* indicates yellow hue (the higher the value the yellower the sample). Each sample was measured at four places (two on the left and two on the right side of the breast). In PS muscle pH value was measured in two parallels. In each bird the temperature of the carcass after chilling was taken at the breastbone. Since pH values were determined in fast-chilled groups 2-3 hours *post mortem* (pH_{3h}) and in slow-chilled groups after 6-7 hours the pH values were measured again in the fast-chilled groups 7-8 hours *post mortem*. In all four groups the pH value measured was designated $pH_{6\text{-}8h}$.

The following day the breasts were thermally treated up to T_i =85oC and subjected to transverse cutting with INSTRON (desk model 1111) universal test apparatus. Measurements of the PS muscle were taken in three parallels.

RESULTS AND DISCUSSION

Table1 shows basic statistical parameters for all measurements in the chickens.

Table 1

Statistical parameters for physical, sensory and equipment-measured parameters of poultry meat

Parameter	N	Mean(1)	Min.	Max.	CV (%)
pH_{45min}	318	6.53	5.95	7.00	3.35
pH_{3h}	154	6.19	5.77	6.78	3.67
$pH_{6\text{-}8h}$	314	5.98	5.54	6.67	2.52
$Temperature_{45min}$(oC)	159	29.14	22.40	35.90	10.17
$Temperature_{6\text{-}8h}$(oC)	157	4.10	1.70	6.60	21.28
Mass (g)(2)	157	1609	1010	2130	12
Colour hue (1-3-5)(3)	157	3.95	0.50	6.00	20.23
Colour uniformity (1-7)(4)	157	5.56	5.00	6.00	6.63
Damage (1-3)(5)	470	1.27	1.00	5.00	32.78
L^*	471	53.79	47.40	64.00	5.07
a^*	471	0.36	-1.40	2.10	169.34
b^*	471	3.01	-0.50	7.50	50.92
Cutting value (N)(6)	474	30.04	11.00	98.00	39.25

CV - coefficient of variability

*Explanation below in text (*Erklärung im folgenden Text)*

1. Tabelle Statistische Merkmale für physisch, sinnlich und technisch gemessene Parameter bei Geflügelfleisch

Mittelwert(1), Masse(2), Farbschattierung(3), Gleichfarbigkeit(4), Verlust(5), Schlachtwert(6)

Table 2 shows three sources of variability (chilling rate, rearing conditions and interaction between chilling and rearing conditions) for some traits. The P value calculated shows the strength of some sources of variability or effects on some parameters. The effects on the chicken samples of the repeated taking of measurements are not significant, and are not shown in the table.

Table 2

Sources of variability and statistical significance (P) of their effect on physical sensory and equipment-measured parameters of poultry meat

	Source of variability (P value) (1)		
	Chilling (2)	Conditions of rearing (3)	Chilling* conditions of rearing (4)
Parameter / DF	1	1	1
pH_{45min}	0.5940	0.2131	**0.0008**
pH_{3h}		**0.0001**	
pH_{6-8h}	**0.0009**	0.6882	0.1838
$Temperature_{45min}$(oC)	**0.0007**	**0.0202**	**0.0001**
$Temperature_{6-8h}$(oC)	**0.0011**	0.8228	**0.0004**
Mass (g)(5)	0.1256	0.1630	0.8255
Colour hue (1-3-5)(6)	0.3871	0.0578	**0.0009**
Colour uniformity (1-7)(7)	0.4763	0.1444	0.4487
Damage (1-3)(8)	**0.0001**	0.2623	0.7345
L^*	**0.0068**	**0.0048**	0.1434
a^*	**0.0022**	0.6341	0.3722
b^*	**0.0014**	0.5386	**0.0001**
Cutting value (N)(9)	**0.0043**	**0.0034**	0.2882

P≤0.001 highly stat. Significant *(stark statistisch signifikant)*; P≤0.01, P≤0.05 stat. Significant *(statistisch signifikant)*; DF: degree of freedom *(Freiheitsgrad)*
* Explanation in text *(Erklärung im Text)*

2. Tabelle: Einfluss der verschiedenen und statistisch signifikanten (P) Quellen auf die physische, sinnlich und technisch gemessenen Parameter bei Geflügelfleisch

Variabilitätsquelle (P-Wert)(1), Kühlung(2), Zuchtbedingungen(3), Kühlumstände(4), Gewicht(5), Farbschattierung(6), Gleichfarbigkeit(7), Verlust(8), Schlachtwert(9)

Chilling rate significantly affects all equipment-measured parameters of colour, pH_{6-8h} and cutting value after thermal treatment. Also, conditions of rearing (i.e., airing) affect some parameters such as L* value and cutting value. The effects of airing and chilling interact and significantly affect the colour hue of breasts (assessed by a sensory technique) and the initial pH value.

The next two tables show the above effects in detail. The differences in temperature are technical and did not influence the experiment. Damage proved more frequent in the case of the fast-chilled chickens, but this was not derived from chilling speed, and was random. The very low Pearson's coefficients of correlation between damage and colour (colour hue 0.031; L* -0.020; a* 0.024; b* 0.080) show that no relations existed among them.

The slow-chilled breasts were darker, and more red or yellow, as was established by *Froning* (1995). Sensory assessment of the hue of these breasts showed almost optimal pink colour. The slow-chilled breasts were slightly brighter in colour (although care should be taken in drawing conclusions, as this was not true in the case of both breeders).

The cutting value of the fast-chilled thermally treated breasts was significantly higher than that of the more slowly chilled ones.

Table 3

The influence of chilling on physical, sensory and equipment-measured parameters of poultry meat (Tukey test)

Parameter(1)	Group (2)	LSM	SEM	Difference between chilling(3) fast - slow	P value
pH_{45min}	fast	6.54	0.02	0.02	0.594
	slow	6.52	0.02		
pH_{3h}	fast	6.19	0.01		
pH_{6-8h}	fast	5.95	0.01	-0.06	**0.0009**
	slow	6.01	0.01		
$Temperature_{45min}$ (°C)	fast	29.88	0.30	1.46	**0.001**
	slow	28.42	0.30		
$Temperature_{6-8h}$(°C)	fast	3.87	0.09	-0.44	**0.001**
	slow	4.31	0.09		
Mass (g)(4)	fast	1633	22	49	0.126
	slow	1584	22		
Colour hue (1-3-5)(5)	fast	4.00	0.09	0.11	0.387
	slow	3.89	0.09		
Colour uniformity (1-7)(6)	fast	5.54	0.04	-0.04	**0.476**
	slow	5.58	0.04		
Damage (1-3)(7)	fast	1.37	0.02	0.21	**0.0001**
	slow	1.16	0.02		
L^*	fast	53.45	0.17	-0.67	**0.007**
	slow	54.12	0.17		
a^*	fast	0.44	0.04	0.17	**0.002**
	slow	0.27	0.04		
b^*	fast	3.24	0.09	0.45	**0.001**
	slow	2.79	0.09		
Cutting value (N)(8)	fast	31.64	0.75	3.07	**0.004**
	slow	28.57	0.75		

LSM - least square mean *(Kleinstes quadratische Mittel),* SEM - standard error mean *(Standart Fehlerwert)*

*Explanation in text (*Erklärung im Text)*

3. Tabelle: Einfluss der Kühlung auf die physische, sinnlich und technisch gemessenen Parameter bei Geflügelfleisch (Tukeytest)

Parameter(1), Gruppe(2), Kühldifferenz(3), Gewicht(4), Farbschattierung(5), Gleichfarbigkeit(6), Verlust (7), Schlachtwert(8)

Table 4

The influence of rearing conditions on physical, sensory and equipment-measured parameters of poultry meat

Parameter	Group	LSM	SEM	(1)Difference between conditions of rearing, 1–2	P value
pH_{45min}	1	6.54	0.02	0.03	0.213
	2	6.51	0.02		
pH_{3h}	1	6.29	0.02	0.20	**0.0001**
	2	6.09	0.02		
pH_{6-8h}	1	5.97	0.01	-0.01	0.6882
	2	5.98	0.01		
$Temperature_{45min}$ (°C)	1	29.65	0.30	0.99	**0.020**
	2	28.66	0.30		
$Temperature_{6-8h}$ (°C)	1	4.10	0.09	0.02	0.823
	2	4.08	0.09		
Mass (g)	1	1587	22	-44	0.163
	2	1631	22		
Colour hue (1-3-5)	1	4.07	0.09	0.24	**0.058**
	2	3.83	0.09		
Colour uniformity (1-7)	1	5.60	0.04	0.08	0.144
	2	5.52	0.04		
Damage (1-3)	1	1.29	0.03	0.04	0.262
	2	1.25	0.03		
L^*	1	53.43	0.17	-0.70	**0.005**
	2	54.13	0.17		
a^*	1	0.37	0.04	0.03	0.634
	2	0.34	0.04		
b^*	1	3.06	0.10	0.09	0.539
	2	2.97	0.10		
Cutting value (N)	1	31.68	0.76	3.15	**0.003**
	2	28.53	0.74		

1 - Low amount of ammonia in air *(Weniger Ammonium in der Luft),* 2 - High amount of ammonia in air *(Viel Ammonium in der Luft)*
*Explanation in text (*Erklärung im Text)*

4. Tabelle: Einfluss der Zuchtbedingungen auf die physische, sinnlich und technisch gemessenen Parameter bei Geflügelfleisch

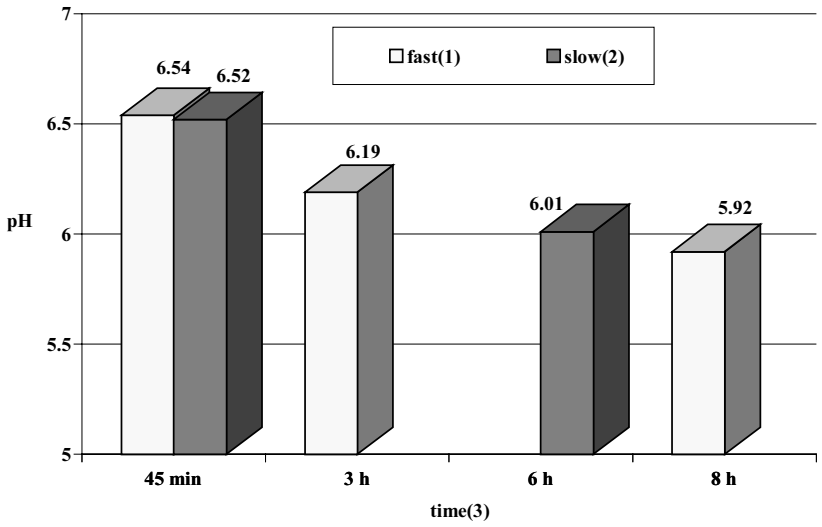
Unterschiede in den Zuchtbedingungen(1), Weitere Bezeichnungen wie in Tabelle 3.

The effect of rearing conditions was evident in two important traits: chickens from better aired cages had darker colour after slaughter (L* value P=0.005: colour hue differed greatly from that for the chickens from less well aired cages, but this difference was not statistically significant). These results are in accordance with the findings of *Sackett et al.*

(1986). The difference in cutting value after thermal treatment was significant. The breasts of the groups of birds reared in cages with lower presence of ammonia were firmer.

Figure 1

Dynamics of post mortem pH value in the breast muscles of chickens related to different types of chilling



1. Abbildung: Der pH-Wert im Brustmuskel von Broilernbei bei verschiedenen Kühlmethoden

Schnell(1), Langsam (2), Zeitdauer(3)

Figure 1 shows whether glycolysis was completed 4 hours *post mortem*. Clearly, the pH value continued to decrease even 6 hours *post mortem*. The difference between pH 6.01 and pH 5.92 is statistically significant (P=0.0009). This observation is surprising. Generally, in normal conditions glycolysis is completed by 4 hours *post mortem* (*Addis*, 1986).

CONCLUSIONS

In comparison to the fast-chilled chickens, the slow-chilled carcasses

- displayed brighter and less intensive colour of the breast (measured by equipment, but not by sensory techniques);
- had significantly more tender texture after thermal treatment.

Better aired cages resulted in

- slightly darker breast colour (low L* value);
- optimal sensory-determined colour.

Variability in breast colour with respect to hue: the fast-chilled breasts from the first breeder (chickens reared in well aired cages) were significantly pinker than the slow-

chilled breasts and also than the fast-chilled breasts from the second breeder (chickens reared in badly aired cages). Glycolysis was not completed even 6 hours *post mortem*.

REFERENCES

Addis, P.B. (1986). Poultry muscle as food. In: Bechtel, P.J. (Ed.) Muscle as Food, Academic Press, New York, 371 - 404.

Allen, C.D., Russell, S.M., Fletcher, D.L. (1997). The relationship of broiler breast meat colour and pH to shelflife and odor development. Poultry Sci., 76. 1042-1046.

Babji, A.S., Froning, G.W., Ngoka, D.A. (1982). The effect of preslaughter environmental temperature in the presence of electrolyte treatment on turkey meat quality. Poultry Sci., 61. 2385-2389.

Froning, G.W. (1995). Colour of poultry meat. Poultry and Avian Biology Reviews, 6. 1. 83-93.

Locker, R.H., Hagyard, C.J. (1963). A cold shortening effect in beef muscles. J. Sci. Food Agric., 14. 787.

Ngoka, D. A., Froning, G.W. (1982). Effect of free struggle and preslaughter excitement on colour of turkey breast muscles. Poultry Sci., 61. 2291-2293.

Sackett, B.A.M., Froning, G.W., De Chazer, J.A., Struwe, F.J. (1986). Effect of Gaseous preslaughter environment on chicken broiler meat quality. Poultry Sci., 65. 511-519.

SAS (1990) *SAS/STAT User's Guide*, SAS Inst., Ins., Cary, NC.

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