International Journal of Agronomy and Agricultural Research (IJAAR)
ISSN: 2223-7054 (Print) 2225-3610 (Online)
http://www.innspub.net
Vol. 26, No. 2, p. 19-32, 2025

RESEARCH PAPER OPEN ACCESS

Influence of pre-slaughter rest duration on carcass and meat quality of indigenous chicken stressed by capture chase

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Article published on February 08, 2025

Key words: Breeding, Fowl, Pre-slaughter norms, Waiting

Abstract

Mastering the influence of pre-slaughter stress on animal products is importance. This study aimed to improve carcass and meat qualities of local chicken from traditional breeding system slaughtered after capture stress. Forty-eight local chickens of 6-7 months divided into four homogenous groups were used. Chickens of group A were not chased before slaughter while groups B, C and D chickens underwent respectively 4, 2 and 0 hours of rest following 15 minutes of capture chase. Carcass, meat organoleptic and technological qualities were evaluated. Wings yield was higher in chickens immediately slaughtered after catching than in control chickens and those rested for 2 and 4 hours, which showed similar values ($p < 0.001$). Control breast pH was similar to those of 2 and 4 hours of rest with higher values than chickens slaughtered without rest at 1, 4, 8, 12, 16 and 20 hours ($p<0,05$). In the thigh at 24 hours, chickens slaughtered without rest had the highest pH and the control had the lowest, similar to that of 4-hour rest chickens. In the breast on the slaughter day, birds without rest had higher meat lightness, yellow index and chroma than the other three groups which were similar. In males, the meat global acceptance of control chickens was lower than those of 2 and 4-hour rest chickens but similar to that of chickens immediately slaughtered. Thus, after a capture chase stress of 15 minutes, 2 and 4 hours of rest start to improve meat organoleptic and technological qualities in local chicken.

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Introduction

Stress is a behavioral, physiological and emotional state of the animal facing a situation it perceives as threatening to the functioning of its bodily or mental state (Terlouw, 2005; Bonou *et al*., 2017e). It is the body reaction to a stimulus that disrupts its normal physiological balance or homeostasis (Lara *et al*., 2013) and is characterized by the activation of autonomic and neuroendocrine nervous systems. In an animal to be slaughtered, it can be caused by several factors including capture and loading in a cage, loading in a vehicle, transport, internal and external climatic conditions, destination period, feed withdrawal and waiting time (Petracci *et al*., 2010; Radu *et al*., 2012; Tamzil *et al*., 2019). These stress factors can negatively affect production (Lara *et al*., 2013), animal welfare (Voslarova *et al*., 2007) as well as carcass and meat quality (Radu *et al*., 2012; Tamzil *et al*., 2019) with consequences on food and health security. Therefore, in a bid to prevent these consequences, studies related to the influence of pre-slaughter stress conditions and to the control of meat and carcass quality variations caused by these conditions are being initiated in several countries throughout America, Europe, Asia and Africa (González *et al*., 2007; Minka and Ayo., 2007; Minka *et al*., 2009; Frimpong *et al*., 2014; Perai *et al* ., 2014; Zhang *et al*., 2014; Tougan *et al*., 2016; Bonou *et al*., 2017a, b, c and d; Tamzil *et al*., 2019). Diverse paths have been explored to improve the quality of exotic animal's products. Meanwhile in many Sub-Saharan African countries, such research works on local animal species are limited.

In Benin, the attention is first focused on local chicken whose pre-slaughter conditions are particularly stressful due to its breeding and marketing system. A study characterizing transport, capture chase and pre-slaughter waiting carried out in the Atlantic Department, one of the smallest Departments of the country, revealed durations of significant stress conditions. According to Bonou *et al*. (2017d), chickens are chased and captured for 8 to 19.1 minutes then, some are transported over 7.10 to 59.72 km for 33 to 169 minutes in cages, baskets or simply tied in clusters and hung up upside down with occurrence of accidents, illness or death. At the end of this study, a series of research on the influence of pre-slaughter stress conditions on the quality of carcass and meat from these chickens was carried out. The work successively evaluated the influence of transport and capture chase stress (Bonou *et al*., 2017a), the influence of capture chase duration (Bonou *et al*., 2017b) and that of pre-slaughter transport duration (Bonou *et al*., 2017c). A study also investigated the effect of feed withdrawal duration on carcass and meat quality of local chicken (Tougan *et al*., 2016). This various work has revealed huge consequences on the organoleptic and technological quality of meat with risks for the products' preservability and for the health safety of the consumer.

For example, studies on the influence of capture chase and its duration have shown meat with abnormal coloring, very low acidity during the 48 hours after slaughter or even abnormally high initial and low final acidity which can favor proliferation of pathogenic microorganisms. It is therefore imperative to explore local possibilities for the improvement of the meat quality from indigenous chicken in view of its pre-slaughter stress conditions, especially those of capture chase. One apparently easy possibility is the rest given to chickens after capture chase and prior to slaughter. It is also generally recommended in slaughter procedures. But which rest duration would be sufficient to ensure good quality of local chicken products after its capture conditions? The present study is initiated to provide answer to this concern with the main objective of improving carcass and meat qualities of local chicken from traditional breeding system slaughtered after capture chase stress. Specifically, it aims to evaluate the effect of the rest duration before slaughter on i) the carcass quality of local chicken under capture chase stress and ii) the technological and organoleptic meat quality of local chicken under capture chase stress.

Materials and methods

Area of study

The study was carried out at the Laboratory of Animal Biotechnology and Meat Technology and at the Laboratory of Food Sciences which are respectively components of the Polytechnic School of Abomey-Calavi and of the Faculty of Agronomic Sciences, both units of the University of Abomey-Calavi (UAC). The chickens used were produced under traditional breeding system in Abomey-Calavi. This township is in the south of Benin Republic, precisely in the Department of Atlantic. It is limited to the North by the township of Zè, to the South by Atlantic Ocean, to the East by the township of Sô-Ava and Cotonou, and to the West by the township of Tori-Bossito and Ouidah. The area has subequatorial climatic conditions characterized by two rainy seasons with an uneven spatial and temporal repartition of rainfall. The major season is from April to July and the minor from September to November. These seasons are separated by two dry seasons. Average rainfall is close to 1200 mm per year. The monthly average temperatures vary between 27°C and 31°C. The relative air humidity fluctuates between 65% from January to March and 97% from June to July.

Animal breeding and sampling

Forty-eight (48) local chickens of six to seven months produced from two (2) roosters and ten (10) hens all of South ecotype of Benin were used. These chickens were reared under traditional breeding system where they have a henhouse for night housing or protection against bad weather and a front yard of 400 m². They fed themselves around and also received grains, agricultural by-products and kitchen rests. Birds were vaccinated against fowl pox using Diftosec® vaccine and against Newcastle disease using Itanew® vaccine. On the eve of the slaughter day, chickens were divided into four homogeneous groups of 6 males and 6 females each and registered.

Pre-slaughter conditions, slaughter process and carcass cutting

On the slaughter day's eve, chickens were weighed using a 2500 g scale with precision of 20 g and then divided into four homogeneous groups (A to D) of six males and six females each. With their identification numbers, the groups chickens were kept separately until the next morning in a henhouse giving access to a 400 m² courtyard intended for pre-slaughter capture chase. Thus, on each slaughter day, chickens to be chased were released by turn onto the courtyard and underwent a 15-minute chase involving three people. The birds in group B were chased from 7:45 a.m. to 8 a.m., those in group C from 9:45 a.m. to 10 a.m. and those in groups D from 11:45 a.m. to 12 p.m. Following the captures, they were slaughtered after a rest of 4 hours, 2 hours and 0 hour respectively. The group A chickens did not undergo capture chase.

The chickens were simultaneously slaughtered at 12 o'clock by jugular vein section then, scalded in a hot water (75°C) and plucked manually. The legs were sectioned at the tarsometatarsal joint level and the head were separated from the neck at the skull-atlas junction. The abdominal and thoracic cavities organs were taken off. Hot carcasses have been weighed and immediately cut. Birds from all groups underwent a feed withdrawal period of 6 hours.

Data collecting

Live weight before slaughter, hot carcass weight and carcass cuts weight (breast, wings, thigh-drumstick) were registered. Carcass yield was determined from the live weight and the percentage of each carcass cut from the hot carcass weight.

The pH was measured in the right slice of the breast muscle (*Pectoralis major*) and in the right thigh muscle (*Iliotibialis superficialis*) at 2 cm depth with a portable pH-meter (HANNA Instrument R, Italy) provided with a specialized probe and a temperature control system. Measures were taken at 1 h, 4 h, 8 h, 12 h, 16 h, 20 h, 24 h and 48 h after slaughter. For every measure, 5 repetitions were performed. On each measure day, the pH-meter has been calibrated previously with two buffers pH-meter: pH 4 and pH 7 following a procedure described by the manufacturer.

The drip loss was determined with the left slice of the breast muscle according to the procedure described by Honikel (1987). Each sample was hung to a hook, put into a refrigeration bag without touching its bottom. After 24 hours at 4°C in hung position, the samples were taken out of the bag without touching the bottom that contains the draining juice. They were mopped, weighted and drip loss was calculated as the percentage of weight loss during the storage.

After that, each sample was put in a cooking bag and carefully sealed manually without trapping air. The samples were placed in a water bath and cooked at a core temperature of 75°C. Finally, they were taken out of the bags and cooled to room temperature in trays. The juice loss during cooking was determined by the difference between the weight before and after cooking.

The meat color was determined using a Minolta Chromameter CR-400 (Japan) in the trichromatic system (CIE L*a*b *) based on three dimensional space with one dimension for luminance (L* is the lightness) and two for color a* (a* is the redness) and b * (b* is the yellowness) (Zhang and Barbut, 2005). The chroma (C) and the hue angle (h) were determined as followed: $C= (a^{*2}+ b^{*2})^{1/2}$ and $h = \tan^{-1}b^*/a^*$. For each measure, 5 repetitions were performed. The measures were taken on the ventral face, at the third superior on the thickest part of the left slice of breast muscle and on the middle of the ventral face of the left thigh muscle. The Minolta was calibrated using standard color tiles. The color was measured on the slaughter day and at 24 hours *post mortem*.

The right slice of the *Pectoralis major* of each chicken was used for the sensory analysis. The samples were put in cooking bags separately without seasoning and boiled in a water bath until the meat core temperature reached 75°C. A trained jury of 10 members was used for the test. After cooling to room temperature, each sample of cooked meat was cut into ten identical pieces at least. Every judge received in a plate divided in four parts of different colors a piece of meat of the same sex of each chicken group and filled in a recapitulative results form. Thus, four samples of which one by group were put by turn in the plate under numbers 1 to 4. The judges have appreciated the tenderness, the juiciness, the flavor and the global acceptance of the meat under marks going from 1 to 5.

Statistical analysis

The data collected on carcass and meat quality were analyzed using SAS (Statistical Analysis System, 2013) software. General Linear Model procedure was used for variance analysis. Fisher test was used to test the significance of rest duration, sex effects on carcass and meat quality traits and their interaction. For each group, averages were calculated using Proc means procedure and they were compared pairwise by Student test.

Results

Carcass traits according to rest duration in local chickens stressed by capture chase

Carcass characteristics according to rest duration in local chickens stressed by capture chase are presented in Table 1. Live weight, hot carcass weight, breast weight, thigh-drumstick weight, wings weight as well as their yields except that of the wings did not vary according to rest duration in chickens stressed by capture chase ($p>0.05$). On the other hand, wings yield was higher in local chickens slaughtered immediately after capture chase than in control chickens and those having undergone 2 hours and 4 hours of rest ($p<0.001$). These last three groups of chickens had similar wings yields. From one sex to another, only wings yield also varied (Table 2) and was higher in females than males of birds immediately slaughtered after capture chase stress ($p<0.001$).

Variation in pH and water holding capacity of meat according to rest duration in local chickens stressed by capture chase

The variation in pH of *Pectoralis major* (breast) and *Iliotibialis superficalis* (thigh) muscles according to rest duration in chickens stressed by capture chase is presented in Table 3. In the breast, pH of control

chickens was similar to those of 2 hours and 4 hours chickens with higher values than those of chickens slaughtered without rest after capture chase at 1, 4, 8, 12, 16 and 20 hours after slaughter ($p<0.05$). At 24 hours and 48 hours after slaughter, pH of control chickens was similar to that of chickens slaughtered immediately after the chase with values lower than those of the birds having undergone 2 hours and 4 hours of rest after the capture chase. In the thigh, at 1 hour, 8 hours, 12 hours and 48 hours after slaughter, pH values of the four groups were different and the lowest pH was recorded in the control chickens followed respectively by the 4 hours of rest chickens, the 2 hours of rest chickens and those slaughtered without rest after capture chase. At 4 hours after slaughter, this same trend was observed but with similar pH for chickens of 2 hours and 4 hours of rest. At 16 hours and 20 hours after slaughter, pH of control group was lower than that of 4 hours of rest chickens which was also lower than that of birds slaughtered without rest after stress. Meanwhile, chickens from 2 hours of rest had an intermediate pH value simultaneously similar to those of the last two groups (0 hours and 4 hours of rest). At 24 hours, chickens slaughtered immediately after capture chase had the highest pH value and the control chickens had the lowest value which was similar to that of 4 hours of rest chickens of which pH was also similar to that of 2 hours of rest chickens. However, the pH of the latter was higher than that of the control chickens.

Table 1. Carcass characteristics and water holding capacity of *Pectoralis major* according to rest duration in local chickens stressed by capture chase

Variable	NC	CR0	CR2	CR4	S.E.	ANOVA
Live weight (g)	698.33a	630.16a	668.33a	659.16a	30.24	NS
Hot carcass weight (g)	430.58a	384.58a	420.58a	404.16a	20.96	NS
Breast weight (g)	117.18a	98.35a	116.41a	108.19a	6.94	NS
Thigh-drumustick weight (g)	129.05a	123.18a	127.45a	122.98a	6.20	NS
Wings weight (g)	59.87a	56.10a	58.52a	61.35a	3.30	NS
Hot carcass yield (%)	61.50a	60.71a	63.51a	61.33a	1.52	NS
Breast yield (%)	16.70a	15.48a	17.66a	16.46a	0.73	NS
Thigh-drumustick yield (%)	18.40a	19.49a	19.25a	26.16a	3.78	NS
Wings yield (%)	8.59a	13.17b	8.80a	9.31a	0.53	***
Drip loss (%)	0.74a	1.23a	0.60a	0.65a	0.26	NS
Cooking loss (%)	6.40a	6.27a	6.15a	6.14a	0.58	NS

NC: non chassés ; NC: not chased ; CR0 : chased and slaughtered without rest ; CR2 : chased and slaughtered after 2 hours of rest ; CR4 : chased and slaughtered after 4 hours of rest ; NS : $p>0.05$; * : $p<0.05$; Averages of the same row followed by different letters differ significantly at the threshold of 5%

Table 2. Carcass characteristics and water holding capacity of *Pectoralis major* according to rest duration in males and females local chickens stressed by capture chase

Variable	NC		CR0		CR2		CR4		S.E.	ANOVA
	Female	Male	Female	Male	Female	Male	Female	Male		
Live weight (g)	660.00a	736.66a	585.00a	675.33a	618.33a	718.33a	591.66a	726.66a	42.77	NS
Hot carcass weight (g)	407.83a	453.33a	358.33a	410.83a	400.33a	440.83a	363.33a	445.00a	29.65	NS
Breast weight (g)	112.75a	121.60a	94.50a	102.63a	116.32a	116.50a	101.59a	114.79a	9.82	NS
Thigh-drumustick weight (g)	120.93a	137.16a	113.31a	133.05a	116.05a	138.75a	107.21a	138.75a	8.76	NS
Wings weight (g)	53.10a	66.63a	51.45a	60.74a	54.40a	62.64a	55.20a	67.49a	4.64	NS
Hot carcass yield (%)	61.88a	61.12a	61.05a	60.37a	65.76a	61.27a	61.27a	61.52a	2.15	NS
Breast yield (%)	17.10a	16.31a	15.99a	14.94a	19.22a	16.11a	17.07a	15.86a	1.03	NS
Thigh-drumustick yield (%)	18.34a	18.46a	19.30a	19.68a	19.24a	19.25a	33.06a	19.25a	5.35	NS
Wings yield (%)	8.09a	9.09a	17.43b	8.90a	8.94a	9.67a	9.24a	9.38a	0.76	***
Drip loss (%)	0.89a	0.59a	1.52a	0.95a	0.61a	0.60a	0.62a	0.69a	0.37	NS
Cooking loss (%)	6.39a	6.42a	6.10a	6.43a	6.28a	6.03a	6.05a	6.23a	0.82	NS

NC: non chassés ; NC: not chased ; CR0 : chased and slaughtered without rest ; CR2 : chased and slaughtered after 2 hours of rest ; CR4 : chased and slaughtered after 4 hours of rest ; NS : $p>0.05$; *** : $p<0.001$; Intraclass averages of the same row followed by different letters differ significantly at the threshold of 5%

Table 3. Variation in breast and thigh meat pH according to rest duration in local chickens stressed by capture chase

Moment (hour)	Muscle	NC	CR0	CR2	CR4	S.E.	ANOVA
1	Breast	5.70a	5.50b	5.70a	5.74a	0.04	*
	Thigh	5.91a	6.41d	6.21c	6.09b	0.03	*
4	Breast	5.68a	5.52b	5.65a	5.70a	0.03	*
	Thigh	5.87a	6.42c	6.21b	6.13b	0.03	*
8	Breast	5.62a	5.46b	5.64a	5.67a	0.02	*
	Thigh	5.89a	6.38d	6.24c	6.14b	0.03	*
12	Breast	5.62a	5.48b	5.63a	5.70a	0.02	*
	Thigh	5.84a	6.34d	6.22c	6.05b	0.03	*
16	Breast	5.59a	5.45b	5.61a	5.65a	0.03	*
	Thigh	5.86a	6.26c	6.23bc	6.12b	0.04	*
20	Breast	5.51a	5.31b	5.52a	5.54a	0.03	*
	Thigh	5.74a	6.26c	6.12bc	6.03b	0.05	*
24	Breast	5.37a	5.39a	5.55b	5.52b	0.04	*
	Thigh	5.99a	6.35c	6.12b	6.04ba	0.03	**
48	Breast	5.33a	5.37a	5.63b	5.52b	5.04	**
	Thigh	5.74a	6.41d	6.12c	5.95b	0.04	**

NC: non chassés ; NC: not chased ; CR0 : chased and slaughtered without rest ; CR2 : chased and slaughtered after 2 hours of rest ; CR4 : chased and slaughtered after 4 hours of rest ; * : $p<0.05$; ** : $p<0.01$; Averages of the same row followed by different letters differ significantly at the threshold of 5%

Table 4. Variation in breast and thigh meat pH according to rest duration in males and females local chickens stressed by capture chase

Moment (hour)	Muscle	CN		CR0		CR2		CR4		S.E.	ANOVA
		Female	Male	Female	Male	Female	Male	Female	Male		
1	Breast	5.53a	5.86a	5.40a	5.60a	5.52a	5.88a	5.65a	5.82a	0.05	NS
	Thigh	5.79a	6.03b	6.38a	6.43a	6.08a	6.33b	6.12a	6.06a	0.04	*
4	Breast	5.70a	5.65a	5.52a	5.52a	5.59a	5.71a	5.73a	5.68a	0.05	NS
	Thigh	5.76a	5.98b	6.38a	6.46a	6.07a	6.35b	6.12a	6.13a	0.04	*
8	Breast	5.49a	5.75b	5.45a	5.46a	5.53b	5.75a	5.64a	5.71a	0.04	***
	Thigh	5.76a	6.02b	6.30a	6.45b	6.38b	6.30a	6.14a	6.14a	0.05	*
12	Breast	5.51a	5.73a	5.43a	5.53a	5.52a	5.73a	5.65a	5.74a	0.04	NS
	Thigh	5.76a	5.91a	6.29a	6.38a	6.10a	6.34a	6.03a	6.07a	0.05	NS
16	Breast	5.50a	5.68a	5.39a	5.51a	5.50a	5.71a	5.65a	5.66a	0.04	NS
	Thigh	5.84a	5.88a	6.20a	6.33a	6.09a	6.37b	6.18a	6.06a	0.06	*
20	Breast	5.39a	5.64a	5.28a	5.34a	5.42a	5.61a	5.49a	5.59a	0.05	NS
	Thigh	5.63a	5.85a	6.29a	6.24a	5.98a	6.27a	6.03a	6.03a	0.07	NS
	Breast	5.46a	5.29b	5.37a	5.41a	5.47a	5.63a	5.63b	5.41a	0.06	
	Thigh	5.99a	5.98a	6.36a	6.34a	6.07a	6.16a	5.99a	6.09a	0.05	NS
48	Breast	5.41a	5.25a	5.39a	5.35a	5.49a	5.78b	5.55a	5.50a	0.05	*
	Thigh	5.66a	5.83a	6.40a	6.41a	5.92a	6.32b	6.00a	5.89a	0.06	*

NC: not chased ; CR0 : chased and slaughtered without rest ; CR2 : chased and slaughtered after 2 hours of rest ; CR4 : chased and slaughtered after 4 hours of rest ; NS : $p>0.05$; * : $p<0.05$; *** : $p<0.001$; Intraclass averages of the same row followed by different letters differ significantly at the threshold of 5%

The variation in pH of breast and thigh according to sex in control chickens and those of the different rest durations after pre-slaughter capture chase stress is presented in Table 4. In the breast, pH of males was higher than that of females in control chickens at 8 hours and at 24 hours and in 2 hours of rest chickens at 8 hours and at 48 hours. But at 24 hours after slaughter, females had the highest pH value in 4 hours of rest chickens. In the thigh, pH of males was higher than that of females in the control group at 1 hour, 4 hours and 8 hours, in the slaughtered without post-stress rest at 8 hours and then in 2 hours of rest chickens at 1 hour, 4 hours, 16 hours and 48 hours after slaughter. On the other hand, for this last group, the opposite trend was observed for both sexes at 8 hours ($p<0.05$).

The results of water holding capacity according to the rest duration and sex are presented respectively in

Tables 4 and 5. Drip loss and cooking loss did not vary according to rest duration after capture chase (table 1), nor according to sex (Table 2).

Color of Pectoralis major and Iliotibialis superficalis muscles according to rest duration in local chickens stressed by capture chase

The effect of rest duration on color of *Pectoralis major* and *Iliotibialis superficalis* muscles in chickens stressed by capture chase on the slaughter day and at 24 hours after slaughter is presented in Table 5. On the slaughter day and in the thigh, the highest meat lightness was recorded in control chickens with a similar value to that of 4 hours of rest chickens whose lightness was also not different from that of chickens slaughtered without rest. The 2 hours of rest chickens had the lowest meat lightness that was similar to the one of birds slaughtered without rest after stress. Meanwhile, in the breast, chickens slaughtered immediately after capture chase had higher lightness, yellow index and meat chromacity than chickens from the other three groups whose values were similar. At 24 hours after slaughter, the breast lightness of chickens from the control group was higher than that of the immediately slaughtered ones which had a similar value with the 2 hours of rest chickens. At this time, the 4-hour rest chickens had the lowest breast lightness which was not different from that of the 2-hour rest chickens. The lowest yellow index and breast chromacity values were observed in 4 hours of rest chickens compared to those from the other groups whose values were similar. However, the meat yellow index of control chickens was not statistically different from that of those having undergone 4 hours of rest after pre-slaughter capture chase stress.

Table 5. Color of *Pectoralis major* and *Iliotibialis superficalis* muscles according to rest duration in local chickens stressed by capture chase

Moment	Muscle	Variable	NC	CR0	CR2	CR4	S.E.	ANOVA
Slaughter day	Thigh	L*	83.31a	81.54bc	80.48c	82.73ab	0.51	*
		a*	7.20a	7.09a	7.92a	7.24a	0.26	NS
		b*	4.56a	3.90a	4.41a	4.51a	0.30	NS
		Hue angle	1.69a	3.12a	1.85a	2.18a	0.49	NS
		Chromacity	8.62a	8.40a	9.29a	8.70a	0.32	NS
	Breast	L*	83.75a	87.71b	84.08a	84.70a	0.58	*
		a*	6.00a	5.51a	5.07a	5.56a	0.32a	NS
		b*	7.28a	9.11b	7.68a	6.97a	0.32	*
		Hue angle	0.23a	-0.30a	0.21a	0.30a	0.16	NS
		Chromacity	9.59a	11.41b	9.54a	9.03a	0.32	*
24 hours after slaughter	Thigh	L*	81.07a	81.25a	80.30a	80.55a	0.59	NS
		a*	8.00a	7.49a	8.22a	7.91a	0.49	NS
		b*	5.22a	5.51a	5.58a	5.46a	0.50	NS
		Hue angle	3.82a	2.31a	2.30a	3.33a	1.09	NS
		Chromacity	9.93a	10.18a	10.38a	10.21a	0.47	NS
	Breast	L*	86.42c	84.41b	82.90ab	81.97a	0.66	*
		a*	5.97a	6.38a	5.71a	6.01a	0.29	NS
		b*	7.26ab	8.00b	8.02b	6.39a	0.41	*
		Hue angle	0.48a	0.44a	-0.20a	0.71a	0.27	NS
		Chromacity	10.02b	10.53b	10.26b	9.01a	0.35	*

L* : lightness ; a* : red index ; b* : yellow index ; NC: non chassés ; NC: not chased ; CR0 : chased and slaughtered without rest ; CR2 : chased and slaughtered after 2 hours of rest ; CR4 : chased and slaughtered after 4 hours of rest ; NS : $p>0.05$; * : $p<0.05$; Averages of the same row followed by different letters differ significantly at the threshold of 5%

The variation in meat color by sex in local chickens stressed by capture chase or not and having rested or not before slaughter is presented in Table 6. Meat lightness of males was higher than that of females in the thigh on the slaughter day in chickens from the control group. This same trend was observed for the breast hue on the slaughter day in chickens slaughtered immediately after the capture chase and

for the breast yellow index of the control group chickens at 24 hours after slaughter. On the other hand, the thigh lightness and the breast hue of males were lower than those of females respectively at 24 hours after slaughter in chickens slaughtered without rest after capture chase and on the slaughter day in chickens that were not chased before slaughter. This same trend was observed for breast yellow index and chromacity at 24 hours after slaughter in chickens having undergone 2-hour rest after capture chase.

Table 6. Color of *Pectoralis major* and *Iliotibialis superficalis* muscles according to rest duration in males and females local chickens stressed by capture chase

Moment	Muscle	Variable	NC		CR0		CR2		CR4		S.E.	ANOVA
	Thigh		Female	Male	Female	Male	Female	Male	Female	Male		
		L*	81.04a	85.59b	81.25a	81.83a	81.27a	79.69a	82.49a	82.98a	0.73	*
		a*	7.35a	7.06a	7.21a	6.97a	7.53a	8.32a	7.15a	7.32a	0.37	NS
		b*	4.53a	4.60a	4.37a	4.43a	4.81a	4.00a	5.05a	3.97a	0.42	NS
Slaughter		Hue angle	1.85a	1.53a	2.14a	4.10a	1.90a	1.80a	1.48a	2.87a	0.70	NS
day		Chromacity	8.73a	8.51a	8.65a	8.16a	9.13a	9.45a	8.90a	8.50a	0.45	NS
	Breast	L*	82.68a	84.82a	88.92a	86.50a	84.55a	83.62a	83.59a	85.80a	0.82	NS
		a*	6.43a	5.56a	4.83a	6.18a	4.45a	5.70a	5.66a	5.45a	0.45	NS
		b*	6.99a	7.58a	10.11a	8.11a	8.17a	7.19a	6.97a	6.98a	0.45	NS
		Hue angle	0.64b	-0.17a	-1.00a	0.40b	0.14a	0.28a	0.33a	0.28a	0.23	**
		Chromacity	9.65a	9.52a	12.05a	10.77a	9.86a	9.23a	9.10a	8.96a	0.42	NS
	Thigh	L*	80.00a	82.14a	83.44b	79.05a	80.44a	80.15a	80.05a	81.05a	0.84	*
		a*	8.14a	7.86a	6.73a	8.24a	8.47a	7.98a	8.30a	7.53a	0.56	NS
		b*	4.59a	5.85a	5.90a	5.11a	6.09a	5.07a	5.74a	5.18a	0.70	NS
		Hue angle	5.93a	1.70a	1.77a	2.84a	1.78a	2.81a	3.12a	3.53a	1.54	NS
24 hours		Chromacity	9.67a	10.19a	9.91a	10.44a	10.92a	9.84a	10.57a	9.87a	0.66	NS
after	Breast	L*	87.75a	85.09a	85.53a	83.30a	83.17a	82.63a	81.39a	82.56a	0.93	NS
slaughter		a*	5.95a	6.80a	5.95a	6.80a	5.61a	5.82a	6.21a	5.81a	0.41	NS
		b*	6.18a	8.33b	8.37a	7.63a	9.04b	7.01a	6.72a	6.07a	0.58	*
		Hue angle	0.40a	0.57a	0.21a	0.67a	-0.86a	0.44a	0.72a	0.71a	0.39	NS
		Chromacity	9.39a	10.64a	10.60a	10.45a	11.20b	9.32a	9.47a	8.54a	0.58	*

L* : lightness ; a* : red index ; b* : yellow index ; NC: non chassés ; NC: not chased ; CR0 : chased and slaughtered without rest ; CR2 : chased and slaughtered after 2 hours of rest ; CR4 : chased and slaughtered after 4 hours of rest ; NS : p>0.05 ; * : p<0.05 ; Intraclass averages of the same row followed by different letters differ significantly at the threshold of 5%

Table 7. Sensory quality of *Pectoralis major* according to rest duration in local chickens stressed by capture chase

Sex	Variable	NC	CR0	CR2	CR4	S.E.	ANOVA
Male	Flavor	2.78a	3.10a	3.08a	2.95a	0.09	NS
	Juiciness	2.90a	2.88a	3.01a	3.16a	0.08	NS
	Tenderness	3.31a	3.28a	3.46a	3.55a	0.11	NS
	Global acceptance	3.10a	3.13ab	3.36b	3.43b	0.86	*
Female	Flavor	2.90a	2.95a	2.90a	3.03a	0.09	NS
	Juiciness	2.88a	2.90a	2.96a	3.06a	0.10	NS
	Tenderness	3.41a	3.23a	3.53a	3.46a	0.11	NS
	Global acceptance	3.20a	3.17a	3.30a	3.34a	0.09	NS

NC: not chased ; CR0 : chased and slaughtered without rest ; CR2 : chased and slaughtered after 2 hours of rest ; CR4 : chased and slaughtered after 4 hours of rest ; NS: p>0.05; *: p<0.05; Averages of the same row followed by different letters differ significantly at the threshold of 5%

Sensory analysis of Pectoralis major according to rest duration in local chickens stressed by capture chase

The results of sensory analysis of *Pectoralis major* according to rest duration in local chickens stressed by capture chase are presented in Table 7. In males, flavor, juiciness and tenderness did not vary. On the other hand, the global meat acceptance score of the control chickens was lower than that of the 2-hour and 4-hour rest chickens but similar to that of

chickens slaughtered immediately after capture chase. However, the values recorded in these last three groups were not statistically different. In females, no significant variations were observed for chicken flavor, juiciness, tenderness and global meat acceptance according to capture chase stress and pre-slaughter rest.

Discussion

Carcass traits according to rest duration in local chickens stressed by capture chase

The evaluated carcass quality parameters except wing yield did not vary according to stress and rest duration. Then, the 15 minutes of capture chase stress and the rest durations did not influence the variables for which no difference was observed. This situation must be explained by the not too long chase and rest durations observed. A long rest before slaughter also negatively affects weight parameters due to the starving often observed during this period following the practice of food withdrawal. In addition, even when an animal must continue life on farm after a stressful event, the immune reaction could result in a reduction in food consumption, growth disturbance and weight loss. For example, Sohail *et al.* (2012) recorded in poultry exposed to chronic heat stress, a reduction of 16.4% in food consumption, of 32.6% in body weight and an increase of 25.6% in food conversion ratio. The non-existence of a stress effect on the carcass characteristics in the present study was also reported by Bonou *et al.* (2017a) with 10 minutes of capture chase stress. The study on the influence of pre-slaughter capture chase stress duration also confirmed this observation (Bonou *et al.*, 2017b).

Besides, the higher wing yield recorded in chickens immediately slaughtered after capture chase is due to their arithmetically lower carcass weight. But this low carcass weight is not a fact of stress effect because the live weight of chickens in this group was the smallest even though the difference was not statistically significant. This same reason justifies the higher wings yield in females than in males of this group because the low weights were recorded in female chickens. Apart from the study factors, the weight and yield results obtained in this study are close to those previously reported in the local chicken of southern Benin ecotypes by Youssao *et al.* (2009), Tougan (2010) and Bonou (2018).

Variation in pH and water holding capacity of meat according to rest duration in local chickens stressed by capture chase

In the breast, pH of control chickens was similar to those of 2 hours and 4 hours of rest chickens with higher values than those of chickens slaughtered without rest after capture chase at 1, 4, 8, 12, 16 and 20 hours after slaughter. The 2 hours and 4 hours of rest therefore sufficiently improved the breast pH of chickens at these measurement times. A positive effect of a 2-hour rest in a crate following mechanical capture was reported by Schilling *et al.* (2008) on breast pH of chickens measured 15 minutes after slaughter. The low breast pH value of chickens slaughtered without rest after the capture chase is due to the effect of this stress factor. These chickens had an initial breast pH of 5.50, reflecting an abnormally too high acidification. Lactic acid from reactions of ATP production by glycolysis was still present in the muscle. But this acidification level of the breast seems not due only to the stress effect of the capture chase because, from the first hour already, there was an abnormal acidification in chickens of the other groups also. The recorded values at this time were 5.70, 5.70 and 5.74 respectively in the chickens of the control group, of the 2 hours of rest and of the 4 hours of rest. The initial pH values of these latter groups are around the normal value of pH at 24 and 48 hours reported in chickens which oscillates between 5.7 and 5.8 (Gigaud *et al.*, 2007; Bonou *et al.*, 2017a). There was therefore certainly an unintentional additional stress effect which affected all the chicken groups. This could be due to rainfalls recorded just before slaughter on certain days.

In addition, the improving effect on the breast pH recorded was not significant at 24 hours and 48 hours after slaughter where chickens having undergone the two rest durations had higher pH

than the control group whose pH was similar with that of chickens slaughtered without rest after the chase. The similarity in pH of control and slaughtered chickens without rest after the capture chase is the consequence of the exhaustion of the latter's glycogenic stock so that, their pH which initially was lower, was not able to continue to fall at a speed comparable to that of the control chickens. Bonou *et al.* (2017b) also reported a slowdown in the pH drop speed in chickens chased for 10 and 15 minutes before slaughter compared to the control group during the 12 hours following slaughter. According to Tesseraud *et al.* (2014) and Berri (2015), the ultimate pH depends on the glycogen concentration in muscles at the slaughter. When glycogen stocks are depleted at the time of slaughter, meat pH barely decreases.

In the thigh, at 1 hour, 8 hours, 12 hours and 48 hours after slaughter, pH values of the four chickens groups were different and the lowest pH was recorded in the control chickens followed respectively by the 4 hours of rest chickens, the 2 hours of rest chickens and those slaughtered without rest after pre-slaughter capture chase. The closeness of pH of the two rest durations chickens with that of the control chickens symbolizes the beginning of a positive effect of the rest durations. But this effect was not sufficient at that time because the thigh meat did not have the same acidity as expected. This also explains the thigh pH results at 4 hours, 16 hours and 20 hours where, moreover, the insufficient positive effect of the two rest durations had the same intensity. On the other hand, at 24 hours, a sufficient improving effect of the 4-hour rest was observed on the thigh meat pH of chickens slaughtered under the catching chase conditions of the present study. Indeed, chickens slaughtered immediately after capture chase had the highest pH and the control ones had the lowest pH which was similar to that of the 4 hours of rest chickens whose pH was also similar to that of the 2 hours of rest chickens. However, the 2 hours of rest effect was not entirely satisfactory because these pH values in the concerned chickens were higher than that of the control group.

In the thigh, pH of males was higher than that of females in the control group at 1 hour, 4 hours and 8 hours, in the slaughtered chickens without rest after capture chase at 8 hours and then in 2 hours of rest chickens at 1 hour, 4 hours, 16 hours and 48 hours after slaughter. On the other hand, for this last group, the opposite trend was observed at 8 hours. These variations between sexes are not related to stress or rest because they are observed in both chased and non-chased chickens. They must be explained by the determinism of sex in the variation of chicken meat pH. More in-depth studies will give a better understanding. Results of higher pH in males were, for example, reported by Bonou *et al.* (2017a). Schneider *et al.* (2012) also reported a higher ultimate pH in the breast of males than in that of females (5.96 vs 5.87).

Drip loss and cooking loss did not vary according to capture chase stress and pre-slaughter rest duration, nor according to sex. Bonou *et al.* (2017a and b) also observed no effect of capture stress durations of 5, 10 and 15 minutes on drip loss. The non-existence of difference between the water holding capacity of control and chickens having undergone the two rest durations observed in our study does not indicate a positive effect of the rest. Indeed, there must first be a positive effect of capture stress on the variable before expectation of an improving effect of the rest.

Color of Pectoralis major and Iliotibialis superficalis muscles according to rest duration in local chickens stressed by capture chase

On the slaughter day and in the thigh, the highest meat lightness was recorded in control chickens with a similar value to that of 4 hours of rest chickens whose lightness was also not different from that of chickens slaughtered without rest. This intermediate position of the parameter in the chickens having undergone the 4 hours of rest after capture chase means a starting of a positive effect of this rest duration on the thigh lightness on the slaughter day but which was not at the expectation level yet. Meanwhile in the breast, the similar results obtained in the two rest durations and control chickens

demonstrate a sufficient improving effect. This better positive effect disappeared the next day when the breast lightness was closer to that of the chickens slaughtered without rest after capture chase. On the first day in this muscle, the chickens slaughtered immediately after capture chase had a higher yellow index than the chickens from the other three groups whose values were similar. This similarity means a sufficient positive effect of the 2 and 4 hours of rest durations on the breast yellow index but only on the slaughter day. Schilling *et al.* (2008) had also observed an improving effect of a 2-hour rest in crate on the breast meat color of chickens compared to those slaughtered immediately following a mechanical capture.

Concerning meat color variation according to sex, the lightness of males was higher than that of females in the thigh on the slaughter day in the control group chickens. But thigh lightness and breast hue angle of males were lower than those of females respectively at 24 hours *post-mortem* in chickens slaughtered without rest after capture chase and on the slaughter day in control chickens. Thus, just like pH, these color variations between sexes are neither related to stress nor to rest because they are observed in both chased and non-chased chickens. They must be explained by the determinism of sex in the variation of chicken meat color. More in-depth studies will give a better understanding.

Besides, the color variations are related to the relationships between pH and meat color indices. For example, a negative correlation between pH and meat lightness has been reported (Sheard *et al.*, 2012; Harford *et al.*, 2014; Bonou *et al.*, 2017a; Xing *et al.*, 2015).

Sensory analysis of Pectoralis major according to rest duration in local chickens stressed by capture chase

In males, the global meat acceptance score of control chickens was lower than that of 2-hour and 4-hour-rest chickens but similar with that of chickens slaughtered immediately after capture chase. This similarity means the non-existence of a stress effect of capture chase and then that of rest on the sensory acceptation of males' meat. The absence of variation for the other sensory quality parameters in males and for the whole in females in the present study was similarly reported in by Bonou *et al.* (2017a and b).

Conclusion

The work on the influence of rest duration on carcass and meat quality of local chicken stressed by pre-slaughter capture chase revealed a positive effect of 2 and 4 hours of rest durations but lower with that of 2 hours. In fact, these two rest durations start an improvement of the meat organoleptic and technological quality. The two rest durations improve the acidification of the breast meat at several times and its yellow index on the slaughter day only. As for the thigh meat, the 4 hours of rest only has a positive effect but it is on the acidification. The improvement of meat quality of local chickens stressed by 15 minutes of *ante-mortem* capture chase is therefore more remarkable with 4 hours of rest but it remains limited, especially concerning the thigh meat.

Acknowledgments

The authors thank the respective staffs of the Laboratory of Animal Biotechnology and Meat Technology and of the Laboratory of Food Sciences of the University of Abomey-Calavi (UAC) for facilitating the work.

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