Growth parameters, behavior, and meat and ham quality of heavy pigs subjected to photoperiods of different duration

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Running title: Photoperiod in heavy pigs

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ABSTRACT

In order to attain a good level of animal welfare pigs require a sufficient environmental illumination. Therefore minimum levels for light duration and light intensity have been set up by the European legislation (Directive 2008/120). An experimental trial was designed to determine whether an increased duration of the photophase (up to 16 hours of light per day) could modify the behaviour, productive parameters, meat and ham quality of Italian heavy pigs. Forty crossbred (Large White × Landrace) castrated males pigs (initial average BW: 26 kg) intended for PDO (Protected Designation Origin, according to EU Regulation 1151/2012) dry-cured ham production were raised according to Parma Ham production rules up to the weight of 160kg. Pigs were homogeneously allotted to two experimental groups, each comprising 20 pigs. The Short Photoperiod group (SP) received the minimum mandatory number of hours of light per day (corresponding to 8 hours/day), whereas the Long Photoperiod group (LP) was subjected 16 hours of light per day during the whole production cycle. Light intensity was maintained at 40 lux (*i.e.*, the minimum mandatory level) for both the experimental groups. Growth and slaughtering parameters, carcass traits, fatty acid composition, meat and dry-cured ham quality and animal behaviour were assessed. Pigs in the LP group showed a greater live weight and carcass weight compared to the SP group ($P = 0.005$ and 0.007, respectively). Similarly, hams obtained from the LP group were significantly heavier and their weight losses during the dry-curing period was reduced ($P < 0.01$) when compared to the SP group. No significant differences were detected between the experimental groups as concerns meat and ham quality or fatty acid composition of the subcutaneous fat. Pigs in the LP group spent more time resting and less time pseudo-rooting ($P < 0.01$). Our results indicate that, given an appropriate dark period for animal rest, an increased duration of the photoperiod, even at the lower mandatory light intensity level, can favourably affect growth parameters of heavy pigs without any negative effect on animal behaviour, carcass traits, meat or long-cured ham quality. Therefore rearing pigs in semi-darkness should be considered as a baseless practice, contrary to animal welfare.

Key words: animal welfare, ham quality, heavy pig, light duration, meat quality

INTRODUCTION

In order to guarantee a satisfactory level of animal welfare and to avoid the practice of rearing pigs in semi-darkness, mandatory levels of environmental illumination for pigs are set by the European legislation (EC, 2008) to a minimum of 40 lux for at least 8 hours per day. This provision reflects the existence of a need of pigs in terms of light intensity and duration, which must be fulfilled in order to allow their explorative and social activities and thus ensure the attainment of a sufficient level of animal welfare (EFSA, 2007). If the behavioural and welfare aspects linked to different illumination regimes have already been investigated (Van Putten and Elshof, 1984; Baldwin and Start, 1985; Taylor et al., 2006), their effects on swine growth parameters and on the quality of the derived products have been poorly explored so far. To our knowledge, the only studies on the effects of photoperiod on meat quality were conducted by Virgili & Schivazappa (2002) and Virgili et al. (2002), who found a circannual rhythm for cathepsin B activity in hams, which had been in turn related to the development of excessive softness and other sensorial defects in the hams during the dry-curing period (Parolari et al., 1994; Virgili et al., 1998).

Previous studies from our research group indicated that a longer photophase (14 vs. 8 hours of light over the 24 hours) may have some positive effects on growth parameters and behavioural traits (Martelli et al., 2005), and that a higher light intensity (80 vs. 40 lux) reduces aggressive behaviours of heavy pigs (Martelli et al., 2010). Besides, neither the increase in light intensity (80 vs. 40 lux) nor in the duration of the photophase (14 vs. 8 hours of light) impaired growth parameters, meat or dry-cured ham quality (Sardi et al., 2012). The aim of the present trial was to investigate the effects of a further increase in the duration of the photophase (16 vs. 8 hours of light over the 24 hours) at the minimum mandatory level of light intensity (*i.e.*, 40 lux), on swine behaviour, growth parameters, carcass traits, meat and long-cured hams quality.

MATERIAL AND METHODS

The trial was carried out in the facilities of the Department of Veterinary Medical Sciences of the University of Bologna, Italy, in observance of current Italian legislation implementing European Council Directive 2008/120 on swine protection. The institutional Ethic Committee of the University of Bologna approved the experimental protocol.

Animals, Housing and Feeding

Forty crossbred (Large White × Landrace) castrated males pigs were used in this trial. The average Body Weight (BW) at the beginning of the trial was (26 ± 2.65) kg . Animals were raised until reaching approximately 160 kg BW and a minimum age of 9 months, according to the rules established for Parma Ham production (Consortium for Parma Ham, 1992).

Pigs were kept in collective pens (5 animals per pen) on a totally slatted floor, with a floor space of 1.20 m^2 per pig. Each pen was equipped with a bite drinker and a collective stainless steel feeder (0.3 m wide x 3.5 m long). Environment was enriched by providing steel hanging chains. Pens were located in temperature- and humidity-controlled rooms (RH 65% and T° 22°C) equipped with a forced-air ventilation system. Water was available *ad libitum* through nipple drinkers. In order to meet the pigs' requirements, three commercial diet formulations were used (first phase from 26 to 75 kg BW: 3620 kcal DE/kg DM, CP 17.9% DM; second phase from 75 to 100 kg BW: 3630 kcal DE/kg DM, CP 16.7% DM; third phase from 100 kg BW to slaughtering: 3580 kcal DE/kg DM, CP 15.4% DM). Feed was offered twice a day (at 8:30 and 14:30) as wet (meal to water ratio = 1:3) and, according to traditional practices for Italian heavy pig production, rationed at 9% of the metabolic BW ($BW^{0.75}$), up to a maximum of 2.8 kg dry matter per pig, per day. Pigs were weighed every 7 weeks to adjust the daily rations. Lighting was entirely artificial and was supplied by neon tubes

(OSRAM LUMILUX, cool white, luminous flux 3350 lm, light colour 840, rated colour temperature 4000 K) placed at 280 cm above the floor. Luminous intensity was measured at pig-eye level using a luxmeter device (model HD 8366, Delta Ohm, Italy) and was kept at 40 lux for both groups, corresponding to the minimum mandatory level for light intensity according to EU legislation (European Council Directive 2008/120). During the period of darkness, light intensity was 1.5 lux. Animals were allotted to two experimental groups, each comprising 4 pens of 5 pigs, which were subjected to the following light regimens

- Short Photoperiod (**SP**): pigs received 8 hours of light per day, from 08:00 to 16:00, followed by a 16-hour scotophase (dark period) (**8L:16D**);
- Long Photoperiod (**LP**): pigs received 16 hours of light per day, from 06:00 to 22:00, followed by a 8-hour dark period (**16L:8D**).

Growth Parameters

Pigs were individually weighed at the beginning of the trial, after 155 days and at the end of the trial period to calculate average daily gain (ADG). Feed intake of every replication was recorded daily to calculate the gain-to-feed ratio (G:F). The collection of growing parameters stopped on the 251st day of the trial, when half of the pigs attained the required slaughter BW of 160 kg and were slaughtered. The remaining pigs were kept under the experimental conditions up to the day in which these pigs in turn attained the final body weight of about 160 kg and were transported to the slaughter plant.

Behavioural Traits

Between day 155 and day 251 of the trial (corresponding to the phase between 100 and 160 kg live weight), the behaviour of all pigs was videotaped during the light period (corresponding to 8h in the SP group, 16 hours in the LP group) by means of a digital closed circuit system (Mesa, Arezzo, Italy).

The cameras were mounted on a rail attached to the wall in front of each pen up to 3m above the ground. Pigs were videotaped once every month, corresponding to 4 videotaping sessions for each replication. Videos were examined by a single trained operator and the behavioural pattern was assessed by scan sampling technique at 10 min intervals according to predetermined ethogram for heavy pigs (Martelli et al., 2014) reporting the following behaviours: standing inactive, sitting inactive (dog-sitting), sternal recumbency, lateral recumbency, walking, eating, drinking, chain/bar biting, exploring the floor, social interactions. The choice of videotaping pigs only during the second phase was based on the assumption that behavioural alterations are more likely to occur during this period, when less space per animal is available and feed restriction becomes more severe (Scipioni et al., 2009).

Carcass Traits, Meat and Fat Quality

At the average BW of 160 kg, pigs were transported to a commercial slaughterhouse (the journey lasted about 1 hour). Slaughtering took place after a 15-hour fast and was preceded by electrical stunning. Thereafter, the dressing out percentage was calculated (based on the hot carcass weight) and the lean meat yield of carcasses was assessed by Fat-o-Meater (FOM-SFK, Copenhagen, DK). At 45' post mortem, the pH value of the *Semimembranosus* muscle was measured by means of a portable pH meter (model 250A, Orion Research, Boston, MA). Thereafter, each carcass was dissected into the main commercial cuts, whose weights were recorded. At 24 hours post mortem, a second measurement of the pH value was taken from the *Semimembranosus* muscle. The colour of the lean portion of the thighs (*Biceps femoris* muscle) was assessed, at 24 hours post mortem, according to the CIELAB System (CIE, 1976), using a Minolta Chromameter CR-200 (Minolta Camera Co., Ltd.,Osaka, Japan) equipped with a D65 illuminant. Subcutaneous fat thickness was measured on the outer portion of trimmed fresh legs, vertically at the head of the femur (Consortium for Parma Ham, 1992).

145 Drip loss and cooking loss were evaluated in samples taken from the *Longissimus dorsi* muscle
146 according to the method described by Honikel (1998).
147 Samples of subcutaneous fat (outer and inner layers) were taken in the overhanging area of the *Biceps*
148 *femoris* muscle in order to determine the fatty acid composition by gas chromatograph (HRGC8560
149 Series Mega 2 gas chromatograph; Fisions Instruments, Milan, Italy). Samples were collected from
150 14 randomly-selected thighs per each experimental group. Total lipids were extracted from each
151 sample of subcutaneous fat by means of the chloroform/methanol (2:1, vol/vol) method described by
152 Folch et al. (1957), and measured gravimetrically. Fatty acids were esterified using 5% methanolic
153 hydrogen chloride. The fatty acid methyl esters were separated by gas chromatography using a
154 Supelco SP- 2330 capillary column (30m × 0.25mm, 0.20 μm; Supelco, Bellefonte, PA, USA).
155 Injector and detector temperatures were kept at 220°C and 280°C, respectively. The column was
156 programmed as follows: 140°C for 1 min; the temperature was then raised to 220°C (3°C/min) and
157 held constant for 15 min. Fatty acids were identified by comparing the retention times of the peaks
158 with those of known standards. Results are expressed as percentages of total fatty acids.
159 The Iodine number was assessed according to the AOAC method (AOAC, 2000).
160
161 ***Ham Yield and Quality***
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163 Hams were cured according to Parma Ham production rules (Consortium for Parma Ham, 1992).
164 Thighs were studied over a 18-month curing period. They were weighted before and after trimming,
165 after salting (25-30 days from slaughtering) and at the end of the curing period, in order to calculate
166 the weight losses after the different phases of the curing process. Twenty-eight samples of *Biceps*
167 *femoris* muscle were taken from seasoned hams (fourteen for each group) and analysed for moisture,
168 crude protein, sodium chloride content (AOAC 1995, 2000) and proteolysis index (Careri et al.,
169 1993). Colour was assessed in cured hams both in samples of the *Semimembranosus* muscle and in
170 samples of subcutaneous fat according to the CIELAB System (CIE, 1976), using a Minolta

Chromameter CR-200 (Minolta Camera Co., Ltd.,Osaka, Japan). Subcutaneous fat samples (outer and inner layers) were taken from the skin-covered fat in the overhanging area of the *Biceps femoris* muscle and analysed by gas chromatography as described above (HRGC8560 Series Mega 2 gas chromatograph; Fisions Instruments, Milan, Italy) for fat from the raw thighs. Subcutaneous fat was analysed for Peroxide Value (AOAC, 2000) and Tiobarbituric Acid Reactive Substances (TBARS) according to the method proposed by Wang et al. (2002).

Cured hams were visually evaluated by a panel of five trained experts, who subjectively rated hams based on a predetermined checklist containing the main sensory characteristics of the lean and of the fat portions (Mordenti et al., 2012). The characteristics assessed were lean part firmness, lean colour homogeneity, lean colour bitonality, marbling, ham fatness and fat firmness. Sensory evaluation was expressed on a 10-point scale where 1 was attributed to the absence of the trait and 10 to its maximum presence. An overall evaluation was also given as the total impression the panelist got evaluating a ham, where 10 was attributed to hams with optimal characteristics, whereas 1 was attributed to poor quality hams (Consortium for Parma Ham, Personal Communication).

Statistical Analysis

Data were analysed using the STATISTICA 10 package (StatSoft Inc., 2011). Normality of data was assessed by the Kolmogorov–Smirnov test and the data obtained were submitted to analysis of variance using duration of photoperiod as the main effect. The pen (5 pigs) was taken as the experimental unit for G:F and behavioural observations; individual data were taken to be the experimental unit for ADG, slaughtering parameters, meat, and ham qualitative traits. For nonparametric data (behavioural traits and sensory evaluation of hams), the Mann-Whitney test was used. The significance level for all statistical tests was set at $P < 0.05$.

RESULTS

No occurrence of disease was recorded during the trial.

Growing parameters are shown in table 1. Pigs which were subjected to a longer photoperiod showed an increased body weight after 155 days of trial (P = 0.007). Such a difference is maintained until the end of the trial (P = 0.044 after 251 days). ADG is also higher in the LP than in the SP group during the first phase of the trial (P = 0.010) and the overall ADG is higher in the LP than in the SP group (P = 0.048). Overall G:F results higher in LP group, and the difference is significant (P = 0.044) during in the first period of the trial (up to 155d).

Slaughtering parameters and carcass traits are shown in Table 2. Pigs belonging to the LP group, showed increased live weight at slaughter, and therefore carcass weights (P = 0.005 and 0.007, respectively) compared to their counterparts in SP group. No significant differences were observed between the experimental groups with respect to lean meat percentage calculated by F-o-M or lean and fatty cuts yield.

Similarly, our results did not reveal any significant difference among the groups with respect to the qualitative traits of meat (colour, post-mortem glycolysis, water holding capacity; see Table 3).

Table 4 shows the characteristics of subcutaneous fat of uncured (raw) thighs. Fat thickness was significantly higher in LP than in SP group (P = 0.038). No significant differences were observed between the two groups concerning the single fatty acid content although the LP group showed a tendentially higher content in oleic acid and a tendentially lower content in linoleic acid compared to the SP group (P = 0.10 and P = 0.066, respectively). Consequently, the content of polyunsatured fatty acid (PUFA) was significantly lower, and the MUFA/PUFA ratio was tendentially higher (P = 0.047 and 0.064, respectively) in the LP than in the SP group. Although the difference between the experimental groups was not significant, also the iodine number appears to be the lower in the LP group.

Ham weights and ham weight losses are shown in Table 5. The weight of the thighs before trimming was significantly higher in LP than in SP group (P = 0.001). These differences remained significant

during the following phases of the curing process (trimmed weight, weight after salting and final weight, P= 0.001). Overall weight loss during the dry curing process was lower in hams deriving from pigs belonging to LP compared to SP group (P = 0.01)**.**

As concerns dry-cured hams, no significant differences were observed with respect to moisture, crude protein, proteolysis index, fat and meat colour or fatty acid composition (see Table 6). The only significant difference was related to sodium chloride content, which was lower in LP than in SP group (P = 0.033). Although not significant, dry-cured fat belonging to the LP group showed a positive trend as concerns oxidative stability, in particular as concerns peroxide value, which was lower in the LP than in the SP group. This finding is in agreement with the observation that the loss of PUFAs during dry curing was less extensive in the LP than in the SP group (from 15.19 to 11.71% vs. from 13.61 to 12.26%, respectively).

Sensory analysis of cured hams (data not shown) didn't reveal any significant difference between the experimental groups, although hams from pigs belonging to the LP group scored a higher overall evaluation (7.25 vs. 6.63 points).

Behavioural observations (Table 7) indicate that during the prolonged photophase to which LP pigs were subjected, animals spent more time in lateral recumbency than SP pigs (P < 0.01), increased the total recumbency time (sternal and lateral recumbencies, P < 0.001) and showed a reduction in the percentage of time spent exploring the pen floor, i.e., pseudo-rooting (P < 0.001).

DISCUSSION

It is worth noting that since pigs seem to dislike excessively high light intensities and prefer darkness for sleep (Baldwin & Start, 1985; Taylor et al., 2006), in the present trial light intensity was kept at a moderate range (40 lux, i.e. the minimum mandatory level), and the artificial photoperiod always allowed for an 8-h period of darkness for sleep.

248 The LP group showed better growth parameters (final weight and overall ADG) than the SP group.
249 This difference is mostly due to the first phase of the trial, as confirmed by ADG and G:F, which are
250 significantly different between groups during this period. Overall ADG fell within the limits
251 recommended for the Italian heavy pig production (i.e, below 600g/die on the whole production cycle,
252 since animals must be at least 9 months old at slaughter and the average body weight of each batch
253 must not exceed 160 ± 10 kg, according to the rules established by the Consortium for Parma Ham,
254 1992).
255 Despite their higher slaughtering weight when compared to pigs receiving the minimum mandatory
256 light duration (SP), LP pigs did not show any negative impact on lean cuts yield as was demonstrated
257 by similar F-o-M values and single cut percentages on the whole carcass. This outcome, which agrees
258 with our previous findings obtained on pigs receiving a moderate increase of the light period (Martelli
259 et al., 2005, Sardi et al., 2012) is indicative of an overall higher body development of LP animals,
260 regardless of carcass composition. Taking into account the fact that pigs were fed-restricted, thus the
261 limited differences in feed intake cannot explain a 13% difference for ADG in the first period, other
262 anabolic pathways may be advocated. In this framework an increase of Growth Hormone (GH) cannot
263 be ruled out, even though we did not carry out any specific analyses. Claus and Weiler (1994)
264 hypothesized that the increased daylength during summer may stimulate GH in pigs, and such an
265 effect has been observed in goats (Jin et al., 2012). It has also been demonstrated that darkness
266 produces a decrease in the baseline GH level in pigs of both sexes (Dubreuil et al., 1988) and that GH
267 secretion is increased during resting in lambs (Laurentie et al., 1989). The joint effects of a shorter
268 dark period and a longer time spent resting during light hours may have improved GH secretion and
269 hence overall body development, which would explain the higher body weights at slaughter given an
270 identical carcass composition (similar lean-to-fat ratio). The increased body development, in fact, can
271 be deduced from the fact that LP pigs had higher F and SR values, as recorded by the Fat-o-Meater,
272 therefore the increased carcass weight of LP pigs was due to an increased thickness both of the
273 subcutaneous fat and of the loin, i.e. by the fact that animals were larger, but not fatter.

Besides, the high level of calmness (LP pigs devoted part of their longer light period in resting regardless of the shortening of the scotophase) observed between 100 and 160 kg BW may have reduced the amount of energy consumed (and wasted) through the expression of other behaviours, such as pseudo-rooting and pen exploration, which are typically observable under stressful and/or frustrating conditions. Nevertheless it should be stressed that, facing to overall better growth parameters of LP pigs, differences in ADG and G:F were significant only during the first phase of the trial when no video-recordings were taken.

As concerns animal behaviour, our observations also showed that the prolongation of the photophase determined a redistribution of pigs' activities during the light period. As mentioned, pigs in the LP group spent an increased portion of the photophase in lateral recumbency, indicating that the prolongation of the phtophase did not impair the pigs' possibility to rest. Besides, the reduced percentage of time LP pigs spent exploring the pen structures during the photophase is indicative of how their exploratory behaviour has been, in fact, redistributed along the light hours.

In our previous researches, an increase in light duration from 8 to 14 hours at 70 lux resulted in a significant improvement of ADG and in a tendential increase of slaughtering BW (Martelli et al., 2005; Sardi et al., 2012), whereas a different light intensity did not affect pig's production traits (Martelli et al., 2010). It may therefore be concluded that the further increase in light duration applied in this study (8 vs. 16 hours), although at the minimum recommended light intensity, has an even more evident effect on body growth, with light duration showing a greater impact than light intensity. It is however worth highlighting that this positive effect did not result in an impairment of meat or fat quality. The increased duration of the photoperiod, in fact, determined an increase in subcutaneous fat thickness in the LP group (most likely linked to the higher body development, as explained above), which is in turn associated with an increased MUFA and a reduced PUFA content and with a subsequent increasese in the MUFA/PUFA ratio. These results can be interpreted as a consequence of the different slaughter weights between the experimental groups: an increased slaughter weight is in fact associated with a lower degree of lipid unsaturation. The increase in backfat thickness has been

300 associated with a higher level of saturated and monounsaturated fatty acids and a notable reduction
301 in polyunsaturated fatty acids content (Virgili et al., 2003; Lo Fiego et al., 2005), with subsequent
302 reduction in PUFA to SFA ratio (Raj et al., 2010). This variation in acidic composition can be
303 positively considered, as it makes possible to obtain fat whose characteristics are more suitable for
304 the dry-curing process, being less subjected to lipid oxidation. In this trial, although the difference
305 between the experimental groups was not significant, lower peroxide and TBARS values were
306 observed in the subcutaneous fat of dry-cured hams belonging to the LP group, which could suggest
307 an increased oxidative stability.
308 Overall, the results from the present experiment fall within the ranges reported by other Italian authors
309 with respect to fatty acids profile of raw thighs (Scipioni and Martelli, 2001; Virgili et al., 2003; Lo
310 Fiego et al., 2005; Pugliese et al., 2006; Mordenti et al., 2012; Nannoni et al. 2013a and 2013b). The
311 iodine number was below 70 for all thighs, according to the limit set by Parma Ham production rules
312 (Consortium for Parma Ham, 1992). Ham yields and their weight losses during the curing process
313 reflect the different initial weights of the raw thighs and overall weight losses were more favourable
314 in the LP group.
315 With respect to the quality of the cured hams, the only significant difference found in this trial was a
316 lower sodium chloride content in LP hams. This difference might once again be due to the higher
317 weight of the LP tights, which is likely to have slowed down salt penetration. However, sodium
318 chloride content fell within the limits for Parma Ham production (4.5-6.7%; Consortium for Parma
319 Ham, 1992). This difference could be regarded favourably from a human nutrition standpoint
320 (Ruusunen and Puolanne, 2005). Lastly, the sensory analysis of cured hams did not reveal any
321 significant differences among groups in terms of colour and consistency of the lean and the fat
322 components, although hams belonging to the LP group showed slightly higher overall scores,
323 probably due to the better colour homogeneity of their lean fraction and to their slightly increased
324 fatness.
325

CONCLUSIONS

The specific illumination requirements of pigs are linked to their need to receive an appropriate sensory input and to express their behavioural repertoire. Our previous investigations demonstrated that a moderate increase in light intensity and/or light duration can positively affect heavy pig welfare and/or growth parameters (Martelli et al., 2005, 2010) without affecting dry-cured ham quality (Sardi et al., 2012). The results of the present trial demonstrate that a further increase in the duration of the photoperiod (up to 16 hours of light per day) can, even at the minimum recommended light intensity (40 lux) and given an adequate dark period for rest, improve on one hand pigs growth parameters, and on the other hand ham nutritional and technological quality, without negatively affecting animal behaviour.

Rearing pigs in a semi-darkness environment in order to avoid competitions between the animals is once more confirmed to be a baseless practice; on the contrary, increasing the hours of light does not impair animal ability to rest and calmness level and improves growth parameters.

Once again we wish to stress that behavioural problems, such as aggressions, arising from poor rearing conditions should be solved by addressing the root causes (lack of space, feed inadequacy, barren environment) rather than reducing environmental lighting as it is still inappropriately done by some farmers.

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438

439 Table 1. Productive parameters of heavy pigs subjected to different photoperiods (SP=Short
440 Photoperiod; LP=Long Photoperiod)

	Photoperiod		
	8L:16D (SP)	16L:8D (LP)	SEM[1]
Pigs, n.	20	20	-
Body weight, kg			
Initial live weight	26.1	26.3	0.45
Intermediate weight (155d)	96.3[B]	106.4[A]	8.22
Final weight (251d)	155.4[b]	166.8[a]	15.77
Average daily weight gain (ADG), g/d			
ADG 1-155d	452[B]	518[A]	13.3
ADG 156-251d	616	630	14.9
ADG 1-251d	515[b]	561[a]	11.8
Gain:Feed (G:F) [as-fed basis]			
Replications	4	4	-
G:F 1-155d	0.27[b]	0.30[a]	0.01
G:F 156-251d	0.24	0.25	0.01
G:F 1-251d	0.25	0.28	0.01

441 [A,B] Means within a row with different superscripts differ ($P < 0.01$)
442 [a,b] Means within a row with different superscripts differ ($P < 0.05$)
443 [1] SEM = Standard Error of the Mean
444
445

446

447 Table 2: Slaughtering parameters and carcass quality of heavy pigs subjected to different photoperiods

448 (SP=Short Photoperiod; LP=Long Photoperiod)

	Photoperiod		
	8L:16D (SP)	16L:8D (LP)	SEM[1]
Pigs, n.	20	20	-
Live weight, kg	162.8[B]	175.0[A]	2.27
Cold Carcass weight (CW), kg	132.1[B]	142.5[A]	2.00
Dressing out[2], %	81.4	81.1	0.28
F-o-M F, mm	59.8	63.7	
F-o-M SR, mm	22.7	27.0	
Lean Meat (F-o-M), %	50.15	50.16	0.55
Loin[3], %CW	23.53	23.24	0.17
Tight, %CW	23.82	24.05	0.17
Lean Cuts, %CW	60.8	60.7	0.32
Fat Cuts, %CW	31.7	31.7	0.33
Lean/Fat cuts	1.92	1.91	0.04

449 [A,B] , Means within a row with different superscripts differ ($P < 0.01$)
450 [1] SEM = Standard Error of the Mean
451 [2] Dressing Out % was calculated as Hot Carcass Weight / Live Weight
452 [3]Rachis with ribs

453 Table. 3: Meat quality of heavy pigs subjected to different photoperiods (SP=Short Photoperiod;

454 LP=Long Photoperiod)

	Photoperiod		
	8L:16D (SP)	16L:8D (LP)	SEM[1]
Pigs, n.	20	20	-
pH (*Semimembranosus* muscle)			
pH 45 min	6.16	6.20	0.04
pH 24 h	5.62	5.60	0.01
Colour (*Biceps femoris* muscle)			
L	50.72	50.54	0.40
Hue	0.78	0.77	0.02
Chroma	9.19	8.99	0.25
Water Holding Capacity (*Longissimus dorsi* muscle)			
Drip Loss, %	3.34	3.39	0.13
Cooking Loss, %	20.22	20.50	0.54

455 [1] SEM = Standard Error of the Mean
456 No significant difference was detected at the statistical analysis.
457

458 Table 4: Fatty acid composition of subcutaneous fat from raw thighs of heavy pigs subjected to
459 different photoperiods (SP=Short Photoperiod; LP=Long Photoperiod)

	Photoperiod		SEM[1]
	8L:16D (SP)	16L:8D (LP)	
Samples, n.	14	14	-
Fat thickness, cm	2.47[b]	2.89[a]	0.42
C 14:0, %	1.79	1.63	0.05
C 16:0, %	23.34	23.23	0.24
C 16:1, %	2.13	2.11	0.08
C 18:0, %	12.23	12.42	0.26
C 18:1, %	42.65	44.04	0.58
C 18:2, %	13.86	12.42	0.52
C 18:3, %	0.67	0.57	0.03
C 20:1, %	0.92	0.98	0.02
C 20:4, %	0.67	0.61	0.03
Saturated (SFA), %	37.52	37.45	0.25
Monounsaturated (MUFA), %	45.46	47.13	0.62
Polyunsaturated (PUFA), %	15.19 [b]	13.61 [a]	0.57
UFA/SFA	1.62	1.63	0.03
MUFA/PUFA	3.04 [b]	3.49 [a]	0.13
Iodine number	67.70	65.74	0.71

460 [a,b] Means within a row with different superscripts differ ($P < 0.05$)
461 [1] SEM = standard error of the mean

462 Table 5: Ham weights and weight losses of heavy pigs subjected to different photoperiods (SP=Short

463 Photoperiod; LP=Long Photoperiod)

	Photoperiod		
	8L:16D (SP)	16L:8D (LP)	SEM[1]
Hams, n.	20	20	-
Pre-trimming weight, kg	16.26[B]	17.95[A]	0.28
Trimmed weight (TW), kg	13.33[B]	14.51[A]	0.18
Weight after salting, kg	13.01[B]	14.19[A]	0.18
Final weight (after 18 months), kg	9.16[B]	10.39[A]	0.18
Weight loss after trimming, %	17.85	19.09	0.46
Weight loss after salting, %TW	2.35	2.24	0.18
Weight loss of cured hams, %TW	30.57 [A]	28.43 [B]	0.47

464 [A,B] , Means within a row with different superscripts differ ($P < 0.01$)
465 [1] SEM = Standard Error of the Mean
466

467 Table 6: Chemical composition, oxidation state and colour of cured hams from heavy pigs subjected

468 to different photoperiods (SP=Short Photoperiod; LP=Long Photoperiod)

	Photoperiod		
	8L:16D (SP)	16L:8D (LP)	SEM[1]
Samples, n.	14	14	-
Meat characteristics			
Moisture, %	60.64	61.01	0.41
Crude protein, % (wet basis)	27.36	27.61	0.18
Sodium chloride, % (wet basis)	6.89 [a]	6.32 [b]	0.24
Proteolysis index	25.06	26.56	0.47
Subcutaneous fat oxidation			
Peroxide value	10.0	8.48	0.82
TBARS, MDA mg/kg[2]	1.39	1.32	0.13
Fatty acid composition of subcutaneous fat from cured hams			
Saturated (SFA), %	34.03	34.20	0.21
Monounsaturated (MUFA), %	52.56	52.60	0.51
Polyunsaturated (PUFA), %	11.71	12.26	0.49
Subcutaneous fat colour			
L	70.32	71.35	0.27
Hue	-1.38	-1.32	0.03
Chroma	6.99	6.62	0.13
Meat colour (Semimembranosus muscle)			
L	34.58	35.08	0.67
Hue	0.36	0.31	0.02
Chroma	8.37	8.80	0.47

469 [1] SEM = Standard Error of the Mean

470 [2] Tiobarbituric Acid Reactive Substances, expressed as mg malonaldehyde/kg

471

472

Table 7 – Behavioural patterns of heavy pigs subjected to different photoperiod (SP=Short Photoperiod; LP=Long Photoperiod). Data are expressed as percentage of total observed behaviours.

	Photoperiod		SEM[1]
	8L:16D (SP)	16L:8D (LP)	
Replications, n.	4	4	-
Standing inactive	0.06	0.13	0.04
Sitting inactive	1.41	1.59	0.19
Lateral recumbency	41.40^{B}	52.78^{A}	2.27
Sternal recumbency	34.87	31.91	1.60
Total recumbency	76.26^{B}	84.68^{A}	1.35
Eating	9.13	6.62	0.75
Drinking	0.04	0.12	0.04
Walking	0.02	0.02	0.01
Bar biting	0.08	0.15	0.07
Exploring the floor	12.20^{A}	6.17^{B}	0.87
Others	0.88	0.67	0.23

[1] SEM = Standard Error of the Mean

[A,B] , Means within a row with different superscripts differ (P < 0.01)